PB88-250360

Total Human Exposure and Indoor Air Quality An Automated Bibliography (BLIS) with Summary Abstracts

SRA Technologies, Inc., Alexandria, VA

Prepared for

Environmental Protection Agency, Washington, DC

May 88

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA/600/9-88/011

2.

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
"Total Human Exposure and Indoor Air Quality: An Automated Bibliography (BLIS) with Summary Abstracts"

5. REPORT DATE
May 1988

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
James M. Shackelford, Wayne R. Ott, and Lance A. Wallace

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Office of Acid Deposition, Environmental Monitoring & Quality Assurance
Office of Research and Development, U.S. EPA
Washington, DC 20460

10. PROGRAM ELEMENT NO.
A-101

11. CONTRACT/GRANT NO.
68-01-7379-02

12. SPONSORING AGENCY NAME AND ADDRESS
Same as (9)

13. TYPE OF REPORT AND PERIOD COVERED
Final Report

14. SPONSORING AGENCY CODE
EPA/600/19

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Bibliographic Literature Information System (BLIS) is a computerized data base with brief abstracts that comprehensively reviews literature on total human exposure to environmental pollution. Unpublished draft reports are listed, as well as final reports of the U.S. Government and other countries, reports by governmental research contractors, journal articles, and other contributions. This bibliography covers publications on exposure models, new field data, and newly emerging research methodologies. Although the bibliography covers the entire field of human exposure methodology, emphasis is on those field studies measuring all the concentrations to which people may be exposed, including indoors, outdoors, or in-transit. This report lists the 788 full abstracts and all keywords contained in the BLIS system as of fall of 1987. The 788 abstracts provide a good representation of much of the world literature on total human exposure and indoor air quality. The time period covers 1962 to the end of 1986, with only a few abstracts from early 1987.

Versions of this data base are available on floppy diskettes that can be accessed on MS-DOS computers with two-floppy-disk or hard-disk systems. These computer programs can search for indexed abstracts rapidly and print out combinations of literature citations and full abstracts.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT
RELEASE TO PUBLIC

19. SECURITY CLASS (This Report)
UNCLASSIFIED

20. SECURITY CLASS (This page)
UNCLASSIFIED

21. NO. OF PAGES
466

22. PRICE
A20 38.95

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

United States
Environmental Protection
Agency

Office of Acid Deposition,
Monitoring, and Quality Assurance
Washington DC 20460

EPA 600 9-88 011
May 1988

Research and Development

PB88-250360

EPA

Total Human Exposure and Indoor Air Quality

An Automated Bibliography (BLIS) with Summary Abstracts

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA/600/9-88/011
May 1988

TOTAL HUMAN EXPOSURE AND INDOOR AIR QUALITY

An Automated Bibliography (BLIS) With Summary Abstracts

by

James Shackelford, Wayne Ott, and Lance Wallace

of the

Office of Acid Deposition, Environmental
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Office of Research and Development
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ABSTRACT

The Bibliographic Literature Information System (BLIS) is a computerized data base that provides a comprehensive review of available literature on total human exposure to environmental pollution. Brief abstracts (often condensed versions of the original abstract) are included; if the original document had no abstract, one was prepared. Unpublished draft reports are listed, as well as final reports of the U.S. Government and other countries, reports by governmental research contractors, journal articles, and other contributions to the field of total human exposure research. This bibliography covers publications on exposure models, new field data, and newly emerging research methodologies. Although the bibliography covers the entire field of human exposure methodology, emphasis is on those field studies measuring all the concentrations to which people may be exposed, including indoors, outdoors, or in-transit. This report lists the 788 full abstracts and all keywords contained in the BLIS system as of fall of 1987. The 788 abstracts provide a good representation of much of the world literature on total human exposure and indoor air quality. The time period covers 1962 to the end of 1986, with only a few abstracts from early 1987.

Versions of this data base are available on floppy diskettes that can be accessed on IBM-compatible personal computers. Different versions are available that will run on two-floppy-disk or on hard-disk systems. These computer programs can search for abstracts rapidly and print out desired combinations of literature citations and full abstracts. In practice, these abstracts can serve the user as an "automated index" of the BLIS data base on total human exposure and indoor air quality.

CHAPTER 1

DEVELOPMENT OF BIBLIOGRAPHY

INTRODUCTION

Measuring and modeling human exposure to environmental pollution is a rapidly emerging science. Until the 1970s, very little was known about the actual daily pollutant concentrations to which individuals are exposed. Between 1970 and 1980, a number of field studies of limited size attempted to determine actual human exposure to environmental pollutants. Many of these studies found that actual pollutant concentrations to which people are exposed often differ significantly from the concentrations reported by traditional environmental monitoring networks or those estimated using existing transport models.

This disquieting news suggested that the data base on which some environmental decisions were being based was not adequate for estimating public health risks, because the data did not adequately reflect actual population exposures to pollutants. In response to these concerns, efforts were undertaken to develop crude models that were able to incorporate the missing ingredients of actual exposure. However, these models were not validated by real exposure data, raising doubts about their accuracy.

Today, the early field studies are called "microenvironmental field investigations," and the models incorporating human activities with microenvironmental concentrations are called "human exposure models." A "microenvironment" is a location of relatively homogeneous pollutant concentration (home, office, subway, etc.) that a person occupies during normal daily activities. In a microenvironmental field study, pollutant concentrations are characterized intensively, and attempts are made to identify the sources responsible and to link the sources to the exposures. Microenvironmental field investigations are important to determine indoor air pollution concentrations because indoor locations are one major class of microenvironments. Prior to 1980, nearly all of the indoor air quality field surveys were microenvironmental field investigations. Human exposure models take the field surveys a step further by accounting for the visits people make to individual microenvironments--that is, their "activity patterns."

In the early 1980s, the U.S. Environmental Protection Agency (EPA) undertook several pioneering field studies to demonstrate the feasibility of using humans as the monitoring points. The researchers measured the actual pollutant concentrations that contacted a person's body by measuring concentrations in the air breathed, the food eaten, and the water consumed. Called the Total Exposure Assessment Methodology (TEAM), these field investigations employed representative (probability) samples of the population, thus enabling inferences to be made about the exposures of the larger population of a city or a region with an accuracy never before possible. These investigations also demonstrated our ability to indirectly estimate "dose" (i.e., the quantity of pollutant actually entering the body).

The overall field of human exposure assessment can be subdivided into five general categories:

- Human exposure models
- Measurement methods and instrumentation
- Microenvironmental field studies
- Total exposure assessment methodology studies
- Dosage investigations

EPA designed the Bibliographic Literature Information System (BLIS) to review all existing literature in these five areas. Because the field is relatively new and rapidly emerging, BLIS includes many documents and reports that have not been published in the peer-reviewed literature. It also includes articles dealing with human exposure from scientific and international journals, as well as some reports produced by contractors or Federal agencies.

For each bibliographic entry, EPA's contractor, SRA Technologies, Inc., developed a summary abstract. If a report did not contain an abstract, then one was prepared. If an abstract already existed, it was carefully examined, reviewed, and edited for clarity. Some abstracts were condensed, while others were expanded. Keywords were identified for each abstract. All abstracts were entered into an IBM-PC/compatible personal computer and were edited, alphabetized, and printed. The remainder of this chapter describes the steps in greater detail.

The appendix of this report summarizes all the abstracts contained in the BLIS system as of fall 1987. Abstracts are listed alphabetically, by author. These 788 abstracts are a reasonably good representation of much of the world literature in total human exposure and indoor air quality. The time period covers 1962 to the end of 1986, with only a few abstracts from early 1987.

WHY BLIS WAS DEVELOPED

BLIS was designed to enable editing, searching, retrieving, sorting, and printing selected abstracts on a personal computer (PC) system. Designed to handle relatively small data bases (usually consisting of fewer than 1,000 abstracts), BLIS can search keyworded abstracts very rapidly, usually in less than a second. Currently, BLIS can be viewed as a data base management system containing primarily the literature on indoor air quality and total human exposure from environmental pollutants.

BLIS originally was developed to generate the present report by using its literature-searching capabilities to help us survey the existing literature on indoor air and total human exposure. One of the BLIS programs automatically generates the alphabetized listing of abstracts contained in this report's appendix. It also automatically generates an index at the end of the abstracts, showing the page number on which each BLIS abstract number appears. We found BLIS's capabilities for generating shorter reports, bibliographies, or even answering questions so useful that we are preparing an automated version of BLIS and the present data base for distribution, on request, to professionals working in the field.

Many large-scale information systems are available that operate on mainframe computers with millions of characters of information that can be accessed. However, there are several reasons why BLIS and a personal computer may be more advantageous to the individual than these larger systems. Cost is a prime consideration; mainframe data systems may cost $25 or more per hour to access. These systems frequently require the services of on-site library staff familiar with both the data base and the accessing system.

Another disadvantage of large data systems is that they invariably access reports and journals that were published two or more years before. These systems may not include unrefereed, state-of-the-art papers and/or reports, many of which are in the preparation stage and may not be published for months or years. BLIS can provide access to these unrefereed studies, which can be stored and transmitted from one person to another by mailing a diskette. The recipient can then use the diskette without clerical assistance. The keyword accession allows the user to peruse the literature rapidly for specific subjects.

A final advantage is perhaps more valuable to government agencies such as EPA. With a data base in an expanding area such as indoor air or total human exposure, the number of inquiries from the public, industry, or the Congress sometimes overwhelms the normal response system. BLIS can provide information on scientific data and draft reports that are not widely available and rapidly respond to an inquiry, usually within a few minutes or hours.

HOW TO USE BLIS

The BLIS system currently relies on several computer programs:

- An open copyright word processor (shareware)
- BASIC and compiled versions of the BLIS data base managers
- Utility programs that update the data base
- The PC's disk operating system (DOS)

The compiled BLIS program and its utility programs will be in the public domain and available without a copyright fee. Abstracts are recorded on a diskette as individual DOS files. A user's manual is available from the authors of this report. However, BLIS is in an evolutionary stage, and the software and associated data base are being evaluated and refined. Although a demonstration disk is available on request, further changes are anticipated, and existing documentation soon will be outdated.

The data base manager can identify abstract files quickly by author or keywords (Table 1), and more slowly by searching for any word in the text of the entire data base. In keyword and

TABLE 1

BLIS KEYWORD GLOSSARY

* Undefined terms are in BLIS without any changes to their common meaning.

acephate	*
acetaldehyde	*
acetone	*
acid	*
acrolein	*
activity	human activity pattern data, specifically, data on time spent in each microenvironment
aerosol	*
aircraft	*
Al	aluminum
aldehyde	*
alkane	*
alkylamine	*
allergen	*
amine	*
ammonia	see NH3
ammonium	see NH4
appliance	see source
architecture	study of the design of structures in terms of indoor air aromatic
	*
asbestos	*
Australia	*
azelate	*
bacteria	see microorganism
Belgium	*
bendiocarb	*
benzene	*
benzo-a-anthracene	*
benzo-a-pyrene	*
bibliography	see literature
bicycle	*
biomonitoring	measurement of chemical concentrations in human tissue, blood, urine, or breath
body	human body weight
Br	bromine
breath	see respiration, biomonitoring
Britain	*

(Continued)

TABLE 1 (Continued)

burning	see combustion
butanol	*
Ca	calcium
Canada	*
cancer	see health
carbaryl	*
carbon	*
CCl4	carbon tetrachloride
Cd	cadmium
CH2O	formaldehyde
CH4	methane
CHCl3	chloroform
children	*
chlordane	*
chloride	*
chlorine	see Cl
chloroform	see CHCl3
chlorpyrifos	*
Cl	chlorine
CO	carbon monoxide
CO2	carbon dioxide
coal	*
combustion	*
control	methods for reducing or preventing human exposure to pollutants
cotinine	*
DDT	*
demographic	exposures assessed for subgroups of the general population
Denmark	*
dermal	skin contact with pollutants
design	design of experiments or sampling
diazinon	*
dieldrin	*
distribution	frequency distribution
diurnal	daily variations
dodecyl	a chain of 20 carbon atoms
dose	quantity of pollutant that enters a human body by crossing an external membrane
dry-cleaner	*
dust	*
economic	monetary cost of a scientific study, pollutant exposure, or control method
energy	energy conservation

(Continued)

TABLE 1 (Continued)

Egypt	*
England	see Britain
EPA$	funding for study or publication provided by U.S. EPA.
epidemiology	study of the impact or pollutant exposures on disease distribution in a population
ethylbenzene	*
Europe	*
exposure	contact between a pollutant and an exchange membrane of an organism (lung, gut, skin)
Fe	iron
fenitrothion	*
field	scientific study outside of the investigator's office or laboratory
Finland	*
food	*
foreign	outside the U.S.
formaldehyde	see CH2O
France	*
Freon	*
fungi	see microorganism
gamma-hexachlorocyclohexane	see HCH
gasoline	*
geology	see source
Germany	see West Germany
Great Britain	see Britain
greenhouse	*
halocarbon	a compound containing carbon and any halogen
HCH	hexachlorocyclohexane
HCHO	see CH2O
HCN	hydrogen cyanide
HEAL	Human Exposure Assessment Location; HEAL studies concern methodologies for assessing human exposure and are coordinated by the United Nations Environment Programme and the World Health Organization
health	health effects
heater	see source
heptachlor	*

(Continued)

TABLE 1 (Continued)

hexane	*
hexachlorocyclohexane	see HCH
hexanal	*
home	any human dwelling
hospital	study of pollutants in any medical facility where patients sleep
humidity	water vapor in air
hydrocarbon	*
India	*
indoor	inside a nonmobile man-made structure
industrial	a manufacturing workplace or a factory
infiltration	see ventilation
interior	inside a man-made structure that is not a building, e.g., automobile interior
ion	*
irritant	*
Italy	*
Japan	*
K	potassium
kerosene	*
ketone	*
Korea	*
laboratory	laboratory measurements instead of, or in addition to, field measurements of pollutant concentrations
landfill	*
liability	criminal or civil responsibility for health effects due to pollutant exposure
lindane	*
literature	study was mainly bibliographic, or is a secondary source of information
lung	*
magnesium	see Mg
magnetic	*
malathion	*
manganese	see Mn
mercaptan	*
metal	*
meteorology	see weather
method	measurement method

(Continued)

TABLE 1 (Continued)

methodology	development and validation of experimental or analytical procedures; comparison of these procedures as used in one or more investigations
methylenedianiline	*
methylethylketone	*
Mg	magnesium
microenvironment	a well-defined place in which pollutant concentrations are relatively uniform and measurable
microorganism	bacteria, fungi, viruses, etc.; includes pollen grains
miner	*
Mn	manganese
model	physical or mathematical simulation of pollutant concentrations or movements
mold	see microorganism
monitor	device which makes repetitive measurements of pollutant concentrations
monitoring	*
multimedia	pollutant concentrations measured in several media, e.g., air, water, food, body fluids. See TEAM
multinational	a study involving too many countries to list individually
multipollutant	a study covering too many pollutants to list individually
mutagenicity	see health
N205	nitrogen pentoxide
Na	sodium
NAAQS	National Ambient Air Quality Standard
NEM	NAAQS Exposure Model
Netherlands	*
NH3	ammonia
NH4	ammonium cation
nicotine	*
NIOSH	National Institute for Occupational Safety and Health
nitrate	see NO3
nitric oxide	see NO
nitroarene	*
nitrogen dioxide	see NO2
nitrogen oxides	NOx
nitrosamine	*
NO	nitric oxide
Norway	*

(Continued)

TABLE 1 (Continued)

NO2	nitrogen dioxide
NO3	nitrate anion
NOPES	Non-Occupational Pesticides Exposure Study
NOx	nitrogen oxides
O2	oxygen gas
O3	ozone
octane	*
odor	airborne chemicals detectable by human olfaction
office	*
olefin	*
oral	*
organic	*
organotin	*
OSHA	Occupational Health and Safety Administration
outdoor	not inside any man-made object (includes street canyons but not tunnels)
oxylene	*
PAH	polynuclear aromatic hydrocarbons
paint	*
PAN	peroxyacetylnitrate
particulate	*
pathogen	see microorganism
Pb	lead
PCB	polychlorinated biphenyls
PCP	pentachlorophenol
pentanal	*
PERC	perchloroethylene
permetrin	*
peroxyacetylnitrate	see PAN
personal	*
pesticide	*
phenanthrene	*
phenol	*
phosphate	*
phthalate	*
pinene	*
PNA	see PAH
policy	*
pollen	see microorganism
polynuclear aromatic hydrocarbons	see PAH
polyurethane	*

(Continued)

TABLE 1 (Continued)

population	see distribution
potassium	see K
pregnancy	*
pressure	barometric pressure
propoxur	*
pyrene	*
pyridine	*
QA	quality assurance, or information on data quality control for the described device, method, or study
quinoline	*
radiation	*
radon	*
receptor	organism exposed to a pollutant
regulation	restrictions on pollutant concentrations and/or sources
research	research needs
respiration	breathing
risk	assessment of a threat to human health
ronnel	*
rural	*
sampling analysis	study uses field sampling and laboratory
Saudi Arabia	*
SbH3	stibine
school	*
seasonal	more than one season, e.g., summer and winter
SHAPE	Simulation of Human Air Pollution Exposure (model)
ship	*
shower	*
smoke	*
smoking	passive smoking; environmental tobacco smoke (see combustion)
SO2	sulfur dioxide
SO4	sulfate anion
sodium	see Na
soil	see source
solvent	*
source	study determines or discusses pollutant sources
SOx	sulfur oxides

(Continued)

TABLE 1 (Continued)

stove	see source
statistical	study reports findings of a statistical analysis
stibine	see SbH3
sulfur dioxide	see SO2
sulfate anion	see SO4
styrene	*
Sweden	*
Switzerland	*
tar	*
TEAM	Total Exposure Assessment Methodology--a multimedia study of personal exposure employing stratified random sampling of a population
temperature	*
terminology	*
terpene	*
tetrachloroethane	*
tetrachloroethylene	*
tissue	see biomonitoring
thiocyanite	*
thoron	*
tobacco	see smoking
tolualdehyde	*
toluene	*
trace	trace elements
tunnel	*
track-etch	passive method of measuring intensity of ionizing radiation
trichloroethane	*
trichloroethylene	*
tunnel	*
United Kingdom	see Britain
urine	see biomonitoring
V	vanadium
vanadium	*
vehicle	automobiles, trucks, busses, trains
ventilation	movement of air into, out of, or within a building or vehicle
video	*
vinyl	*
vinylidene	*
virus	see microorganism
VOC	volatile organic compounds

(Continued)

TABLE 1 (Continued)

water	household water
West Germany	*
weather	meteorology data
wood	*
xylene	*
Yugoslavia	*
Zn	zinc

text searches, the files identified can be searched again for secondary words. For example, to find articles about measurements of CO exposure inside vehicles, a sequential search can be done for "CO," "exposure," "vehicle," and "interior".

BLIS can display or print the citation or full abstract of any identified file. References or full abstracts for ranges of file numbers can also be printed, as well as an alphabetical author list and a keyword list. Abstracts, citations, and the author list may be printed darkened, compressed, or double- or single-spaced, when using dot matrix printers.

CRITERIA FOR INCLUSION

The literature search focuses on the following themes:

- Human exposure assessment by means of measuring pollutant concentrations in well-defined indoor, outdoor, and in-transit microenvironments (*e.g.*, vehicle interiors or residential kitchens)
- Personal exposure measurements (single- and multi-media) at or near the boundaries of individual human bodies
- Models of human exposure based on, and validated by (if possible), data on human exposure and personal exposure measurements
- Exposure models based on measured ambient pollutant concentrations (*e.g.*, the NAAQS Exposure Model)
- Sources of indoor pollutants or exposures

Although the human exposure literature covers all studies in which pollutants were observed in contact with humans, the emphasis is on exposures of members of the general public rather than specific occupational groups. Thus, papers on the exposures to pesticides in the general population (*i.e.*,nonoccupational exposures) have been included, while papers on the (occupational) exposures of pesticide applicators have not.

The following journals were searched for information on total human exposure and indoor air quality:

- Environmental Research
  Academic Press, Inc.
  6277 Sea Harbor Drive
  Orlando, FL 32887
  Searched: 1981-August 1986

- Environment International
  P.O. Box 7166
  Alexandria, VA 22307
  Searched: 1980-1986

- Environmental Science and Technology
  1155 16th St. N.W.
  Washington, DC 20036
  Searched: 1968-1986

- Journal of the Air Pollution Control Association
  P.O. Box 2861
  Pittsburgh, PA 15230
  Searched: 1960-1986

- Atmospheric Environment
  Pergamon Journals Ltd.
  Maxwell House, Fairview Park
  Elmsford, NY 10523
  Searched: 1982-August 1986

Articles have been cited from many other journals including Environmental Health Perspectives, Environmental Health, Archives of Environmental Health, Science, Journal of Environmental Health, New England Journal of Medicine, EPRI Journal, American Journal of Public Health, and New York State Journal of Medicine.

In addition, reports of EPA and other Federal agencies were reviewed. These reports are cited in BLIS to allow users to obtain copies.

The Lawrence Berkeley National Laboratory's system for Indoor Air Information Retrieval (Brown et al., 1986) was evaluated and reviewed, as well as other data bases such as the

Data Base on Sources of Indoor Pollutants (Air and Energy Engineering Research Laboratory, Research Triangle Park, NC 27711, Jane Crum, Project Leader). The REFEREE system maintained by EPA's Environmental Criteria and Assessment Office also was reviewed.

Other literature sources were identified as a result of visits by SRA Technologies, Inc., staff to the following people:

- P. Barry Ryan (617) 732-1431
  Robert Treitman (617) 732-1431
  Harvard School of Public Health
  665 Huntington Avenue
  Boston, MA 02175

- Ken Sexton (202) 382-5900
  Director, Office of Health Research (RD-683)
  U.S. Environmental Protection Agency
  Washington,, DC 20460

- David Mage (919) 541-2346
  Gerald Akland (919) 541-3184
  U.S. EPA Environmental Monitoring Systems Laboratory
  Research Triangle Park, NC 27711

- Thomas McCurdy (919) 541-5655
  Donna Sledge (919) 541-5655
  U.S. EPA Office of Air Quality and Standards
  Research Triangle Park, NC 27711

Proceedings of pertinent conferences and symposia were reviewed--for example, meetings of the Air Pollution Control Association (APCA). In addition, many references were gleaned from the bibliographies of reports already in BLIS. Finally, two bibliographic reviews on indoor air quality were screened:

- U.S. EPA (June 1985) "Bibliography on indoor air pollution," EPA/IMSD85-002, U.S. EPA Headquarters Library Staff, Washington, DC 20460 (84 pages).

- Benson, F.B., Henderson, J.J., and Caldwell, D.E. (Aug. 1972) "Indoor-outdoor air pollution relationships: a literature review," Publication AP-112, U.S. EPA, Office of Administrating Technical Publications Branch, Research Triangle Park, NC 27711 (73 pages).

The extensive literature on asbestos exposures was not reviewed. Similarly, the literature on biological aerosols, except as part of other exposure studies, was not extensively reviewed. Studies of all other pollutants and pollutant categories were included.

FORMAT AND ABBREVIATIONS

In general, the BLIS reference citations follow the format used by Environment International. Journal names are abbreviated according to the Chemical Abstracts "CAS Source Index Quarterly Supplement." Some examples include:

Published Article

Chaney, Lucian W. (1978) "Carbon monoxide automobile emissions measured from the interior of a traveling automobile," Science, 199:1203-1204.

Unpublished Report

Hartwell. T.D. *et al*., (Jan. 1984) "Study of carbon monoxide exposure to residents of Washington, D.C. and Denver, Colorado, part I," final report for EPA Contract No. 68-02-3679, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (210 pages). Not available from NTIS.

Paper Presented at a Conference

Lewis, R.G., Bond, A.E., and Fitzsimons, T.R. (June 1986) "Monitoring for non-occupational exposure to pesticides in indoor and personal respiratory air," Paper No. 86-37.4, presented at the 79th Annual Meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (15 pages).

For articles not published in the peer-reviewed literature, BLIS includes a complete mailing address (when available) so that the author(s) or sponsor(s) can be contacted. BLIS also included, whenever possible, the National Technical Information

Service (NTIS) publication number for U.S. government reports. These reports can be obtained directly from NTIS by specifying the order number appearing in the citation. If NTIS does not currently house the article, this fact is also noted in the reference:

- National Technical Information Service
  U.S. Department of Commerce
  5285 Port Royal Road
  Springfield, VA 22041
  (703) 487-4601

Papers presented at APCA conferences or published in JAPCA can be obtained, usually at $5 each, from:

- Air Pollution Control Association
  P.O. Box 2861
  Pittsburgh, PA 15230
  (412) 232-3444

For research sponsored by the U.S. government, but not published by NTIS, the publication number, contract number, grant number, or cooperative agreement number is given if it is available. These numbers may be helpful in locating a report.

Table 2 lists several acronyms and abbreviations used in BLIS (several more are defined in Table 1). Table 3 shows the number of BLIS references by pollutant for three major study types: microenvironmental field measurements, total exposure assessment, and exposure model development. This report contains a subject index prepared with the help of the BLIS keyword-searching system. Such an index is useful in a formal report. It is not needed when the BLIS diskette and its associated data base are available, however, because users can search the words automatically using their personal computers.

TABLE 2

ACRONYMS AND ABBREVIATIONS

Anon	Anonymous
APCA	Air Pollution Control Association (Box 2861, Pittsburgh, PA 15230)
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers (1971 Tullie Circle N.E., Atlanta, GA 30329)
Bq	Becquerels
CAMP	Continuous Air Monitoring Program
COED	Carbon Monoxide Exposure Dosimeter
COHb	Carboxyhemoglobin
GC/FID	Gas Chromatography/Flame Ionization Detector
GC/MS	Gas Chromatography/Mass Spectrometry
HCH	Hexachlorocyclohexane
IAQ	Indoor air quality
IEEE	Institute of Electrical and Electronic Engineers (345 East 47th Street, New York, NY 10017)
IP	Inhalable particulates
Kcal/L	Kilocalories/liter
LBNL or LBL	Lawrence Berkeley National Laboratory (1 Cyclotron Road, Berkeley, CA 94720)
m3	Cubic meters
mg	Milligram
ml or mL	Milliliter
mWL	Milli Working Level
NBS	National Bureau of Standards
NHANES	National Health & Nutrition Examination Survey
NIOSH	National Institute of Occupational Safety and Health
ng	Nanogram
NTIS	National Technical Information Service (5285 Port Royal Road, Springfield, VA 22041)
OHEA	Office of Health & Environmental Assessment (EPA)
OMB	Office of Management & Budget
ORNL	Oak Ridge National Laboratory (Oak Ridge, TN 37831)

(Continued)

TABLE 2 (Continued)

pCi/L	Picocuries/liter
PEM	Personal exposure monitor
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
RTB	Range-top burner
RSD	Relative standard deviation
RSP	Respirable particulates
SIAM	Society for Industrial and Applied Mathematics
SIMS	SIAM Institute of Mathematics and Society (97 Parish Road South, New Canaan, CT 06840)
SIP	State Implementation Plan (Part of NAAQS)
TAMS	Toxic air monitoring site
TSP	Total suspended particulates
UFFI	Urea-formaldehyde foam insulation
uG	Microgram
uL	Microliter
uM	Micrometer

TABLE 3

NUMBER OF BLIS ABSTRACTS BY POLLUTANT FOR THREE MAJOR TYPES OF STUDIES

Pollutant	Microenvironmental Field Measurements	Total Exposure Assessment	Exposure Model Development
CRITERIA POLLUTANTS*			
Carbon monoxide	75	12	20
Nitrogen oxides	50	10	16
Sulfur oxides	17	4	8
Particulates	35	6	16
Inhaled particles	13	5	8
Lead	8	2	3
Ozone	6		4
NONCRITERIA POLLUTANTS*			
Aerosols	4		2
Aluminum	1		
Bromine	1		
Chlorine	3		
Formaldehyde	30	1	6
Halocarbons	8		1
Hexanal	1		
Iron	2		
Manganese	1		
Microorganism	7		
Natural Gas	1		
Nitrosamine	1		
Pentanal	1		
Pesticides	18	2	
Polyaromatic hydrocarbons	7	2	

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* Criteria pollutants are those for which EPA has published air quality criteria documents and established National Ambient Air Quality Standards. Noncriteria pollutants are those for which criteria documents have not been published.

(Continued)

TABLE 3 (Continued)

Pollutant	Microenvironmental Field Measurements	Total Exposure Assessment	Exposure Model Development
NONCRITERIA POLLUTANTS*			
Polychlorinated biphenyls	2		
Radon	40	1	14
Sodium	1		
Toluene	2		1
Trace metals	3		
Volatile organic compounds	23	12	7
Vanadium	1		

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* Criteria pollutants are those for which EPA has published air quality criteria documents and established National Ambient Air Quality Standards. Noncriteria pollutants are those for which criteria documents have not been published.

CHAPTER 2

OVERVIEW OF THE LITERATURE*

INTRODUCTION

Although a large body of the world's literature on total human exposure and indoor air quality is represented in the attached BLIS listing of abstracts and can be easily accessed on a personal computer, this chapter also contains a very brief synopsis of the field, emphasizing the historical development within each pollutant. Because only a few pages can be devoted to each pollutant, this synopsis is, of necessity, very cursory. Nevertheless, it sets the context for the individual abstracts that follow. This synopsis covers the following pollutants:

- Carbon monoxide
- Nitrogen dioxide
- Sulfur dioxide
- Particulates
- Formaldehyde
- Volatile organic compounds
- Pesticides
- Radon

The concept of total human exposure to air pollution is defined theoretically as the time-weighted sum of air pollutants encountered in the microenvironments people progress through in their daily activities. If the monitor has sufficiently fine time resolution, then it is possible to identify the exposures associated with individual activities and microenvironments,

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* Contributing Authors: Carbon Monoxide, Wayne Ott (EPA); Nitrogen Dioxide, Lance Wallace (EPA); Sulfur Dioxide, Peter Mavraganis (SRA) and Karl Held (SRA); Particulates, Jim Shackelford (EPA) and Jim Repace (EPA); Formaldehyde, David Johnson (SRA) and Karl Held (SRA); Volatile Organic Compounds, Lance Wallace (EPA); Pesticides, Jim Shackelford (EPA); and Radon, Richard Toft (SRA) and Karl Held (SRA).

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including indoor microenvironments. It also is possible to study pollutant concentrations in these microenvironments directly and, coupled with time-budget studies, to estimate human exposure profiles and frequency distributions. Adequate microenvironmental field data now exist for only a few pollutants. Experimental data using personal monitors still are required for most pollutants, and time-budget data are very fragmentary. Personal monitoring instruments are at an early stage of development, and indoor monitoring methods and instruments need to be improved for most pollutants. The importance of indoor and in-transit exposures relative to outdoor exposures is not well documented for some pollutants. Nevertheless, much progress has been made in recent years toward quantifying the magnitude of human exposures to environmental pollution and understanding the factors responsible for these exposures.

CARBON MONOXIDE

The internal combustion engine is a major source of carbon monoxide (CO) emissions, and automobiles or trucks operating in confined small spaces, such as parking garages, can cause extremely high CO concentrations. With the introduction of the automobile in the early half of the century, many isolated cases of CO poisoning were reported. The usual victims were automobile repairmen, gas station attendants, or persons accidentally exposed in their own garages.

Until the 1960s, most of the data available on ambient CO concentrations came from fixed monitoring stations operated routinely in urban areas. The accepted measurement technique was by nondispersive infrared (NDIR) spectrometry, but the instruments were large and cumbersome, often requiring vibration-free, air-conditioned enclosures. In late 1960, one of the first systematic studies of CO concentrations was undertaken in the passenger compartments of motor vehicles (Brice and Roessler, 1966). A large, bulky NDIR monitor was installed in a van that traveled to 14 U.S. cities and measured CO concentrations on a number of routes in each city (Lynn et al., 1967). This study showed that passengers of motor vehicles experienced CO exposures higher than those measured by ambient monitoring stations.

Without a portable, convenient monitor for CO, it was extremely difficult to measure CO concentrations accurately in the microenvironments that people usually visited. In 1971, an investigator walked on congested downtown streets alongside pedestrians to measure their exposures (Ott, 1971). With a portable pump, the investigator filled sampling bags in various locations, then transported them to the laboratory where the contents were analyzed by NDIR spectrometry.

In the early 1970s, portable electrochemical monitors about the size of a shoe box became available. Using the ECOlyzer monitor, CO concentrations were measured in traffic in Boston, MA (Cortese, 1976; Cortese and Spengler, 1976).

In the late 1970s, smaller personal monitors using electrochemical sensing systems became available and were deployed in specialized field surveys involving a few people (Jabara et al., 1980). Few other field surveys employed these new devices prompting Repace, Ott, and Wallace (1980) to ask: "If small, portable monitors are available to record CO concentrations continuously, why can't these same monitors be adapted to measure the actual exposure profiles (CO concentrations as a function of time) of individual members of the population?"

In one early pilot investigation (unpublished data by Ott, 1981), a subject carried a General Electric CO personal monitor from San Jose to San Francisco, CA, and back again to simulate a typical commute pattern (8 hours of work and 1 hour driving each way). About 600 observations were recorded during the 10 hours, necessitating the development of suitable data loggers (Fitz-Simmons and Sauls, 1984; Ott et al., 1986).

As CO monitors continued to evolve, they were used in studies of indoor microenvironments. Many of the microenvironmental CO data on indoor concentrations were collected as an integral part of multipollutant indoor health or dosage studies in homes (Lebowitz et al., 1984; Lebowitz et al., 1985), in offices or rooms (Berglund et al., 1982a, b; Hoffman et al., 1984; Hugod, 1984), or as more narrowly focused multipollutant exposure field studies in homes (Quackenboss et al., 1984; Koontz and Nagda, 1984; Traynor et al., 1984) and in buildings (Konopinski, 1984; Malaspina et al., 1984; Clarkson, 1984).

Although the CO personal monitors evolved rapidly, they were not used in large-scale field surveys of indoor microenvironments until the early 1980s. The monitors have been used in studies of CO concentrations in sustained-use vehicles (Ziskind et al., 1981) and in the passenger compartments of vehicles traveling on highways (Ott and Willits, 1981; Flachsbart and Yo, 1986). A large field survey by Flachsbart and Ott (1984; see also Ott and Flachsbart, 1982) showed good agreement when the new CO detectors were carried side by side. A pilot field study of nine people was conducted in about 45 days in winter of 1980-81 to test the CO monitors and examine problems encountered when untrained respondents used the monitors (Ziskind et al., 1981; Ziskind et al., 1982).

Ultimately, small personal exposure monitors were developed that could measure CO concentrations continuously over time and store the readings automatically on internal digital memories (Ott et al., 1986). These small personal exposure monitors (PEMs) made possible the large-scale CO human exposure field studies conducted in Denver, CO, and Washington, DC, in the winter of 1982-83 (Johnson, 1984; Hartwell et al., 1984a; Akland et al., 1985). These monitors proved effective in generating 24-hour CO exposure profiles on more than 1,600 persons. By breaking up the profiles into the microenvironments visited by these people, it was possible to develop CO concentration readings on more than 40 indoor and in-transit microenvironments (Tables 4, 5, and 6).

The PEMs have shown themselves to be a powerful tool for quantifying air quality levels in in-transit, outdoor, and indoor microenvironments. A great number of microenvironments can be compared in one study. For example, Table 4 shows in-transit microenvironments in Denver, Colorado ranked from highest to lowest by arithmetic mean. The worst in-transit microenvironment is the motor vehicle, while walking and bicycling have the lowest CO concentrations. (In this instance, there were too few samples to draw valid conclusions about bicycling). Outdoor microenvironments also can be ranked (Table 5). Outdoor public garages and outdoor residential garages and carports had the highest CO concentrations; outdoor service stations, vehicle repair facilities, and parking lots had intermediate concentrations. In contrast, school grounds and residential grounds had relatively low concentrations, while extremely low CO concentrations were found in outdoor sports arenas, amphitheaters, parks, and golf courses. Finally, a wide range of concentrations was found in indoor microenvironments (Table 6). The highest indoor CO concentrations occurred in service stations, and public garages; intermediate concentrations were found in shopping malls, residential garages, restaurants, offices, auditoriums, sports arenas, concert halls, and stores, and lower concentrations in health care facilities, public buildings, manufacturing facilities, and homes. Of all indoor locations, the lowest levels were observed in schools and churches. Because people spend so much time in indoor locations, the number of observations taken in homes (21,543) and offices (2,287) is quite large; thus, the

TABLE 4

CO CONCENTRATIONS IN IN-TRANSIT MICROENVIRONMENTS - DENVER, COLORADO
(In descending order of mean CO Concentration)

Microenvironment	n	Mean (ppm)	Std. Dev. (ppm)
Motorcycle	22	9.79	8.15
Bus	76	8.52	7.08
Car	3632	8.10	9.88
Truck	405	7.03	9.89
Walking	619	3.88	6.61
Bicycling	9	1.34	3.61

Source: Johnson, 1984

TABLE 5

CO CONCENTRATIONS IN OUTDOOR MICROENVIRONMENTS - DENVER, COLORADO
(Listed in descending order of mean CO Concentration)

Microenvironment	n	Mean (ppm)	Std. Dev. (ppm)
Public Garages	29	8.20	5.33
Residential Garages or Carports	22	7.53	8.93
Service Stations or Vehicle Repair Facilities	12	3.68	3.84
Parking Lots	61	3.45	4.23
Other Locations	126	3.17	5.47
School Grounds	16	1.99	3.39
Residential Grounds	74	1.36	2.24
Sports Arenas, Amphitheaters	29	0.97	2.80
Parks, Golf Courses	21	0.69	1.01

Source: Johnson, 1984

TABLE 6

CO CONCENTRATIONS IN INDOOR MICROENVIRONMENTS - DENVER, COLORADO
(In descending order of mean CO Concentration)

Microenvironment	n	Mean (ppm)	Std. Dev. (ppm)
Public Garages	116	13.46	18.14
Service Stations or Vehicle Repair Facilities	125	9.17	9.33
Other Locations	427	7.40	17.97
Other Repair Shops	55	5.64	7.67
Shoping Malls	58	4.90	6.50
Residential Garages	66	4.35	7.06
Restaurants	524	3.71	4.35
Offices	2287	3.59	4.18
Auditoriums, Sports Arenas, Concert Halls	100	3.37	4.76
Stores	734	3.23	5.56
Health Care Facilities	351	2.22	4.25
Other Public Buildings	115	2.15	3.26
Manufacturing Facilities	42	2.04	2.55
Homes	21543	2.04	2.55
Schools	426	1.64	2.76
Churches	179	1.56	3.35

Source: Johnson, 1984

precision of the indoor CO concentrations in these two types of microenvironments is quite high.

Although these CO PEMs worked effectively, further refinements are needed. Some examples:

- A self-contained portable personal monitor that can operate with high stability in indoor microenvironments for up to a month.
- A low-cost passive monitor that can screen buildings and homes for unusually high CO concentrations.

NITROGEN DIOXIDE

Two main devices are available for measuring integrated exposure to nitrogen dioxide (NO2): the Palmes tube and the Yanagisawa badge. The Palmes tube (Palmes _et al_., 1976) is an acrylic or metal tube, normally about 1 cm in diameter by 7 cm long, containing three stainless steel grids coated with triethanolamine in a cap at the top of the tube. The bottom of the tube is open to sample the air, allowing NO2 to diffuse upward until it reacts with the triethanolamine, forming a stable complex for later analysis by spectrophotometry. The sampler has a sensitivity of several hundred ppb-hours, requiring a minimum 2-day collection time at normal indoor environmental levels. Most studies use 1- to 2-week collection times. The Palmes tube has been used to study the relationship between respiratory illness in children and the use of gas stoves for cooking (Goldstein _et al_., 1979).

The Yanagisawa badge (Yanagisawa and Nishimura, 1982) uses an absorbent sheet of cellulose fiber coated with triethanolamine. A five-layer mat of hydrophobic fiber prevents face velocity from affecting the diffusion characteristics of the badge. The sensitivity of the badge is 66 ppb-hours, about 10 times more sensitive than the Palmes tube. Thus, sampling periods as short as 8 hours at environmental levels are possible. The badge has been used in a study of the effect of unvented heaters on indoor NO2 levels (Yanagisawa et al., 1981).

Major studies of NO2 in indoor air include the Six-City Study of 55 houses, (Spengler, 1979), the Southern California Gas Corporation study (Colome et al., 1986) of 500 houses in the Los Angeles, CA area, and the Harvard University School of Public Health, Gas Research Institute (GRI) study of 500 houses in the Boston, MA, area (Soczek et al., 1986). The latter two studies included the following main components:

- Random selection of clusters of homes
- Two-week measurements using Palmes tubes
- Multiple indoor locations (i.e., kitchen, bedroom, and living room)
- Air exchange measurements using perfluorocarbon tracers (PFT)
- Water vapor measurements
- Outdoor air measurements

Both studies found gas stoves (both the pilot light and cooking operations) to be a major influence on indoor air quality, adding about 30 to 40 ug/m3 NO2 on the average. In addition, wall and floor-vented gas furnaces in the Los Angeles area added roughly equivalent amounts of NO2 causing the Southern California Gas Corporation to fund a followup study of homes with wall and floor furnaces (Wilson et al., 1987). Outdoor NO2 concentrations were elevated in Los Angeles, increasing indoor NO2 more than in Boston, where outdoor concentrations were lower.

Concurrent chamber studies of gas stove emissions at the

Institute for Gas Technology and IIT Research Institute (supported by GRI) have shown that flame color and adjustment affect NO2 emissions far less than CO emissions (I. Billick, personal communication). However, furnace adjustment and maintenance were a serious problem in Los Angeles (30 of the 40 homes with the highest 2-week NO2 averages required repairs).

Future studies needed in this area include personal monitoring studies to answer the difficult question of the influence of indoor concentrations on total exposure. One such study has recently been completed in Boston by the Harvard University School of Public Health, supported by GRI (Ryan et al., 1987). Yanagisawa passive badges were worn by 300 persons at home and at work for 2 consecutive days. Subjects were selected from among those participating in the earlier Harvard/GRI indoor study, with high-concentration homes preferentially selected. A second study is being carried out in Los Angeles by Harvard and the University of California at Irvine, supported by the Southern California Gas Corporation (J. Spengler, personal communication). Again, several hundred persons, selected by a probability sampling technique, are wearing Yanagisawa badges for 1 or 2 days.

SULFUR DIOXIDE

Sulfur dioxide (SO2) in the outdoor environment has been one of the most widely studied gaseous criteria pollutants over the past 75 years (Yocum et al., 1982). The primary source of atmospheric SO2 is from fuel combustion in stationary sources such as power plants and smelters. The main indoor sources of SO2 are leaky or improperly vented furnace flues and unvented kerosene space heaters (Leaderer et al., 1984; Spengler et al., 1979). However, indoor SO2 levels possibly come from outside sources (Colome et al., 1982; Yocum et al., 1982).

In 1964, a pioneering study examined indoor/outdoor relationships for SO2 and particulates in 60 homes in Rotterdam, The Netherlands (Yocum, 1982). The results showed differences between indoor and outdoor air quality and also showed that indoor air quality could be of concern to human health.

To obtain a more accurate picture of human exposure to SO2, researchers have been investigating the relationships between indoor and outdoor concentrations. For example, Spengler et al. (1979) monitored indoor and outdoor levels of SO2 (and NO2) in six communities for a year. Two of the communities had violations of the annual National Ambient Air Quality Standards (NAAQS) for outdoor SO2, while the other four had SO2 levels of less than 50 percent of the annual standard. Indoor levels in all communities, however, never exceeded the standard and ranged from 20 to 70 percent of recorded outdoor levels.

Similarly, Colome et al. (1982) compared indoor and outdoor concentrations of SO2 (and other pollutants) at 10 homes in Steubenville, OH, and Portage, WI. During the 1-year study, researchers found that indoor SO2 levels were lower than the corresponding outdoor levels. In a study of two Paris, France, office buildings, Malaspina et al., (1984) found that, of the 11 pollutants monitored, SO2 was the only one that had lower levels indoors than outdoors. Nasralla (1980) found that in a public library in Egypt the indoor/outdoor ratio for SO2 was 0.6. Pengelly et al., (1983) monitored schools and residences in Hamilton, Ontario, in two 5-day sessions during the heating and nonheating seasons. Indoor levels of SO2 correlated with outdoor levels.

For the past several years, increased energy costs have led to increased insulation, better weatherization, and auxiliary heating methods to reduce costs. One popular method of auxiliary heating is the unvented kerosene heater; Leaderer et al. (1984) estimate that more than 10 million heaters are used in the United

States. This has given rise to the concern that combustion of kerosene fuel in the home could result in large increases in indoor SO2 levels. Recent studies indicate some reason for concern. Leaderer et al. (1984), in a study of 303 homes in the New Haven, CT, area, found that SO2 levels during heater use were four to five times greater than the average values measured during the sampling period. Moreover, 21.4 percent of these residences had average SO2 concentrations greater than the 24-hour NAAQS health standard of 365 ug/m3.

Ritchie and Arnold (1984) also studied residential air pollution from unvented kerosene heaters. They found that indoor SO2 exceeded the 0.14-ppm limit recommended by the American Society of Heating, Refrigeration, and Air Conditioning Engineers. The increased use of auxiliary heating methods that can burn sulfur-based fuel, coupled with the "tightening" of homes to promote energy efficiency, can significantly increase SO2 levels indoors over outdoors. Obviously, this increase would be most serious during the winter. In buildings using kerosene heaters and no other open combustion sources, Ryan et al., (1983) concluded that modeling of SO2 concentrations and exposures suggests very high levels of SO2 in residences that are poorly ventilated or have small-mixing volumes.

More work is needed in several areas to obtain more accurate exposure data for health effects studies and to mitigate potential increases in indoor SO2 sources. To determine the health effects more accurately, actual human exposure patterns must be more closely linked to monitoring programs. This suggests that additional research should be done on establishing the relationships between ambient concentrations and actual exposures (Spengler and Soczek, 1984; Silverman et al., 1984; Khan and Meranger, 1983). Additional research is needed on improving the burners of unvented kerosene heaters to reduce SO2 and other emissions.

PARTICULATES

Interest in particulates intensified in the early 1950s and 1960s with the acute episodes of illnesses and deaths in London, New York, Detroit, and Osaka. The resulting concern for human health and the intense public outcry influenced the U.S. Public Health Service to publish the "Air Quality Criteria for Particulate Matter" in 1969. This document, an almost encyclopedic examination of the published literature relating to particulate matter, led to establishment of the Clean Air Act, NAAQS, and the State Implementation Plans (SIPs) to control particulate emissions. The literature cited in the document did not cover dose-response relationships--perhaps because of the scarcity of data or perhaps a measure of the limited knowledge or concern at that time.

The literature in the air quality criteria document was extensive regarding methods of measuring particulates, perhaps the greatest number relating to outdoor high volume filters, dust buckets, impingers, and impactors. Emphasis was placed on measuring weight of total suspended particulates; little or no reference was made to indoor, inhaled particulates, which are now considered one of the most important parts of human exposure. Likewise, little reference was made to anything except the solid phase. No one was concerned with adsorbed matter such as metals, liquids, or vapors, all of which are of concern when dealing with human exposure.

BLIS does not attempt to duplicate the references in the air quality criteria document but, instead, focuses on work on total human exposure to air pollutants published after 1969. The 1984 symposium sponsored by the Swedish Council for Building Research (Berglund et al., 1984, 1986), much of which is covered in BLIS, provides a broad background of the worldwide interest in indoor air pollution and human exposure.

During the early 1980s, many studies focused on determining sources of indoor particulates. Nasralla (1980) measured indoor air pollutants in Egypt. Girman et al. (1982) measured in the laboratory emissions from gas-fired stoves, space heaters, kerosene heaters, and tobacco smoke. He found elevated levels of particulates as well as CO, nitrogen oxides, volatile organic compounds (VOCs), and formaldehyde. Squirrel (1985) reported on sources of indoor air pollutants, including combustion processes and tobacco smoke as well as metabolic products from the human body.

At the same time, interest grew in the use of personal monitors to determine total human exposure to particulates. Wallace (1981) and Wallace and Ott (1982) described the monitoring systems then available, the state-of-the-art, and recent progress in developing and using personal exposure monitors. McKenzie et al. (1982), Silverman et al. (1982), Fletcher et al. (1983, 1984) and Howes et al. (1985) reported on the development and use of personal exposure monitors. These latter efforts were mainly devoted to developing and testing personal exposure monitors for inhalable particulates, although allergens also have been studied (Reed and Swanson, 1986). In many instances, the research was designed to monitor several pollutants, such as CO, nitrogen oxides, VOCs, and particulates.

Perhaps the earliest data concerned with human exposure to indoor particulates were more related to lead (Fugas et al., 1972) and pesticides adsorbed on particulates than to the particulates themselves (Starr et al., 1974). In one of the earliest publications, Fugas (1975) used indoor monitoring networks to measure lead. This work showed some of the relationships of indoor/outdoor concentrations in European towns. Shortly thereafter, Binder et al. (1976) determined that the particulate load appeared to be caused more by exposure to indoor, rather than outdoor, pollutants.

At the same time, evidence began to emerge concerning the indoor pollutant load caused by cigarette smoking. Although the earliest work was more concerned with CO, particulate matter from tobacco smoking quickly became an important area of scientific interest. Dockery and Spengler (1977), Repace and Lowrey (1980), Repace (1981), Bock (1982), Girman et al. (1982, 1984), Johnson (1984), and many others demonstrated the widespread effect of smoking on exposure to air pollutants such as particulates, CO, and VOCs.

Only a few years later, it became evident that smoke from wood-burning fireplaces was also a prominent indoor source of particulates. Alfheim (1984) and Sexton et al. (1984, 1985, 1986) demonstrated that indoor pollutant concentrations were significantly higher than outdoors in homes with wood-burning fireplaces. The mutagenic activity was higher when wood was burned in open fireplaces and higher still with tobacco smoke also in the room.

The high cost of fuel nationwide has increased the use of wood-burning furnaces and fireplaces, along with kerosene space heaters. This, combined with more efficient (tighter) homes, has brought attention to the pollutants generated within homes from burning these fuels and the higher concentrations being maintained due to the lower ventilation rates.

Recent work has made it evident that sources of particulates in enclosed spaces such as homes, offices, schools, and vehicles, are not numerous. Excluding, for the moment, outdoor pollutants that may drift indoors, the main indoor sources are fuel combustion and tobacco smoke. Furnaces, fireplaces, space heaters, kitchen stoves, and tobacco smoke provide most of the solid-phase particulates. These same sources also provide undesirable amounts of VOCs, nitrogen oxides, CO, and polycyclic aromatic compounds.

Concern and research programs are increasing throughout Europe and the Third World. Smith et al. (1983) found that the main source of indoor particulates in Third World countries is biomass combustion. Wang et al. (1985) reported on exposure to particulates and CO in China, while other studies in Japan, Sweden, Belgium, Malta, Mexico, Egypt, India, Canada, and The Netherlands report findings about indoor particulate exposure from various sources.

By conventional measures, the quality of ambient air has steadily improved over the years. However, although total suspended particulates may have decreased, human exposures to inhalable particulates probably has increased due to concentrations of fine aerosols and ultrafine particulates generated within homes and offices. In addition, because people tend to spend more than 90 percent of their time indoors, they may be subjected to elevated levels of pollutants from indoor sources. Modern studies tend to assume that central monitoring stations do not reflect or predict actual personal exposures. Continued research is needed on the relationships between ambient concentrations and actual exposure.

FORMALDEHYDE

Formaldehyde vapor has been one of the most publicized contributors to indoor air quality. The principal sources are building materials containing urea-formaldehyde resins, such as plywood, particle board, paneling, and other pressed-wood products (Ritchie and Lehnen, 1985). Urea-formaldehyde foam is also widely used to insulate walls. According to Mage and Gammage (1984), urea-formaldehyde use increased dramatically in the 1960s. Energy conservation techniques led to tighter, less-ventilated houses, which reduced energy loss but increased the indoor concentration of formaldehyde. Grimsrud _et al_. (1986) compared indoor air quality in new, energy-efficient homes versus existing homes and found that new homes, on average, had higher formaldehyde concentrations, smaller leakage areas, and lower ventilation rates. By 1982, the U.S. Consumer Product Safety Commission (CPSC) had received over 3,000 complaints involving exposure to formaldehyde (Gupta _et al_.,1982).

Oak Ridge National Laboratory developed a formaldehyde-monitoring program to assist CPSC in its deliberations concerning the use of urea-formaldehyde foam insulation (Matthews _et al_., 1984). Hawthorne _et al_. (1984) made extensive measurements with passive integrating monitors in 40 east Tennessee homes in 1982. They found that houses less than 5 years old averaged twice the concentration of formaldehyde compared to older houses.

Berglund _et al_. (1982) examined typical contaminants from building materials in a preschool and found that all organic compounds, except formaldehyde, decline in concentration, mainly within the first 6 months of occupancy.

Meyer (1986) performed laboratory tests to study the effects of high temperatures and humidity on formaldehyde indoor air levels. The research showed that large seasonal and diurnal changes occurred in formaldehyde concentrations, resulting in increases by a factor of five in 24 hours. The findings indicated that exposure levels in mobile homes also depend on daytime climatic conditions.

Liu _et al_. (1986a, b) reported the results of a California survey of formaldehyde in 470 mobile homes. They found that the most important factors affecting indoor concentrations were home age, open windows, home location, new furniture, and gas appliances. Ritchie and Lehnen (1985) observed that mobile homes had consistently higher formaldehyde concentrations than conventional homes. Leaderer _et al_. (1984), in a study of houses with kerosene heaters and gas appliances, reported that formaldehyde levels were low and not associated with indoor combustion.

The large-scale monitoring efforts described above were aided by the development of low-cost monitoring technology. Although early methods were bulky, expensive, and complicated, Geisling _et al_. (1982) developed a passive sampling device that is inexpensive, simple to operate, and sensitive. This sampler consists of a capped glass tube (approximate dimensions 2.4 x 9 cm) containing a glass fiber filter treated with sodium bisulfite. After the cap is removed, formaldehyde is absorbed onto the filter. Samples are recapped after 7 days and returned to a laboratory for analysis by the chromatropic method.

Matthews _et al_. (1982) describe new analytical methodologies that provide excellent correlation of results with a reference analysis technique. These include (1) a semipermeable-membrane passive sampler and (2) a visual colorimetric analysis method. Application of these methodologies to personal exposure monitoring is now under investigation.

In a review of health effects of formaldehyde, Gupta _et al_. (1982) concluded that formaldehyde is likely to pose a carcinogenic risk to humans. Formaldehyde is also associated with eye, nose, and throat irritation, respiratory ailments, nausea, and nervous system disorders. Schenker _et al_. (1982) reported that chronic low-level exposure to formaldehyde may cause mental changes such as depression and reduced attention span. In a recent study by Harving _et al_. (1986) on the impact of formaldehyde on lower bronchial airways of hyper-responsive subjects, low concentrations of formaldehyde, known to irritate upper respiratory tract and mucous membranes, were of minor importance in the development of pulmonary symptoms.

A number of control techniques have been explored to reduce formaldehyde emissions in mobile homes. Jewel (1980) demonstrated that ammonia fumigation produced long-term reductions of approximately 61 percent to 73 percent, and use of a high capacity air recirculation filtering device resulted in a 79 percent reduction during operation. Singh et al. (1982) used low-formaldehyde-emitting plywood paneling and particle board to achieve almost 50 percent lower concentrations compared to where materials with high-emitting materials were used.

Although CPSC has banned use of urea-formaldehyde insulation in the United States, formaldehyde is released from numerous other building materials and household items such as furniture, carpets, and paneling. More work is needed to determine the relative importance of each as a source of formaldehyde. Other possible sources of formaldehyde such as combustion and smoking must also be considered. The impact of other factors such as humidity, temperature, product age, ventilation, and seasonal variations on formaldehyde concentrations also need further study.

VOLATILE ORGANIC COMPOUNDS

Many of our most common and useful chemicals are VOCs. Unfortunately, some cause mutations in bacteria and/or cancer in animals or man. Several Federal agencies are authorized to regulate these chemicals. However, before such regulation is undertaken, information must be collected on the sources, health effects, and human exposure to each chemical. In an effort to develop and apply a methodology for determining human exposure to VOCs, EPA developed the Total Exposure Assessment Methodology (TEAM) between 1979 and 1985 (Wallace et al., 1982, 1984a, b, c; Hartwell et al., 1984b, c; Pellizzari et al., 1984b, 1986). The following are the main components of the methodology:

- Personal monitors (with Tenax sampling cartridges and miniature air pumps) to measure exposure directly
- Spirometers to measure exhaled breath as an indicator of recent exposure and body burden
- Measurements of drinking water at the tap
- Outdoor air measurements to determine the ambient component of exposure
- Survey sampling techniques to ensure representativeness of the subjects
- Oversampling of strata of interest to ensure adequate statistical power
- Concurrent special studies to investigate microenvironments of interest (e.g., dry cleaners, swimming pools)

The TEAM study resulted in two major findings:

- Personal exposure exceeded outdoor concentrations for all 11 prevalent chemicals at all tested locations
- Breath concentrations reflected previous exposures

With respect to individual chemicals, four additional observations were made:

- Cigarette smoke is the major source of exposure to benzene and styrene; both were elevated in smokers' breath by factors of 5 to 10 over nonsmokers. Cigarette smoke was another source of elevated exposure to xylenes, octane, and ethylbenzene
- Hot showers appear to be the major source of exposure to chloroform
- Dry-cleaned clothes are the major source of exposure to tetrachloroethylene
- Room air fresheners and moth crystals may be major sources of exposure to para-dichlorobenzene

Lebret et al. (1986) studied 134 homes in The Netherlands using charcoal (rather than Tenax) and using only indoor (rather than personal) samplers. About 45 chemicals were quantified, compared to 20 in the TEAM study. There were two major findings in the Lebret study:

- Indoor levels of all 45 chemicals exceeded outdoor levels
- Tobacco smoke and use of solvents were major sources of elevated indoor pollutant concentrations.

Seven other studies of volatile organics in 10 or more homes have been reported since 1979. Molhave et al. (1979) found elevated levels of benzene and toluene in 39 Danish dwellings. Jarke (1979) found more complex chromatograms and increased concentrations of organics in 34 Chicago, IL, homes. Seifert and Abraham (1982) reported that 15 homes in Berlin, West Germany, displayed increased levels of toluene and xylene from printed material (books, newspapers, etc.). The Halocarbon Study (Pellizzari et al. 1983) has determined 12-hour integrated exposures to 20 to 30 halogenated hydrocarbons in 150 households in three U.S. cities.

De Bortoli et al. (1984) found that 32 of 32 organics had indoor-outdoor ratios greater than 1 in northern Italian homes, with six indoor-outdoor ratios greater than 10. Gammage et al. (1986) detected gasoline vapors in 40 east Tennessee homes, most with attached garages. Monteith (1984) found increased levels of 18 VOCs in 44 mobile homes in Texas.

Nine studies of more than 1,000 homes (Table 7) show remarkable agreement on the following points:

- Essentially every one of the 40 or so organics studied has higher levels indoors than outdoors

TABLE 7

STUDIES OF VOLATILE ORGANICS IN HOMES

Location	Date of Study	No. of Homes	Principal Investigator	BLIS Reference
California	1984	192	Pellizzari, Wallace	211, 437
Denmark	1979	39	Molhave	451
Germany	1981-82	15	Seifert	262
Illinois	1979	34	Jarke	522
Italy	1983	14	De Bortoli	53
Netherlands	1981-82	134	Lebret	100
New Jersey	1980	9	Pellizzari	17
	1981-1983	352	Wallace, Hartwell	51, 76, 127, 136, 719
No. Carolina	1979	6	Wallace	126
	1980	3	Pellizzari	17
	1982	25	Wallace	127
No. Dakota	1982	25	Wallace	127
Ohio	1986	1	Spicer	610
Pennsylvania	1980-84	3	Davidson	80
Tennessee	1986	8	Gammage	615
Texas	1979	11	Wallace	126
	1983	44	Monteith	427
TOTAL		915		

- Sources are numerous, including building materials, furnishings, dry-cleaned clothes, cigarettes, gasoline, cleansers, moth crystals, hot showers, and printed material.

- The range of concentrations is great, often two or more orders of magnitude.

PESTICIDES

Interest in measuring pesticide exposure in indoor air is relatively recent. Few studies on pesticides were conducted in the 1970s. Perhaps the earliest published work is by Starr, et al., (1974), which describes measurements in Colorado and concludes that household dust is a major reservoir for pesticides in the environment. Wright and Jackson (1975) evaluated the variance in pesticide residues, including after application using air compressors and aerosol-type sprayers. They concluded that pesticides move following aerosol application and that food contamination after application was appreciable.

Wright et al. (1981, 1982, 1984) and Leidy (1982, 1984) published a series of papers describing measurements following application of pesticides in dormitories, food-serving areas, buildings, service vehicles, and homes. In each case, measurable amounts were detected in the air, on dust particles, on walls, on articles in the rooms, etc., for as long as 35 days after application.

Pellizzari et al. (1981), Wallace et al., (1983a, b), Bromberg et al. (1984), Jurinski (1984), Ruh (1984), Gebifugi and Korte (1984), Livingston et al. (1981), and Dobbs and Williams (1983) also reported measurable pesticide exposures after residential or commercial applications. In view of these studies, it is not surprising that Melius et al. (1984) published a survey by the National Institute for Occupational Safety and Health of more than 200 buildings where office workers had complained of poor indoor air quality. Wallace (1984) described the "sick building syndrome" and possible solutions that architects may use in designing buildings. Pesticides are undoubtedly a major contributor to the sick building syndrome in many cases. Exposure to biocides is also of concern. Van der Kolk (1984) and Levin and Hahn (1986) reported on human exposure to wood preservatives and concluded that good practices are not universal and that little consideration has been given to occupants of treated homes.

Increased attention is being paid to improving the methodology for measuring pesticides in indoor air, largely because agencies such as EPA are required to measure and monitor low levels of pesticides in the indoor environment. Melcher _et al_. (1978), Lewis _et al_. (1982, 1986), Jackson and Lewis (1981), and Riggin and Petersen (1985) identified methods for increasing sampling sensitivity for a variety of chemicals. Air concentrations of pesticides as low as 0.01 ug/m3 can now be measured with sophisticated laboratory equipment. A portable exposure monitor system is also considered desirable.

One currently accepted method for measuring low levels of most pesticides is through absorption on polyurethane foam (Lewis and MacLeod, 1982). After elution and concentration, the samples are passed through gas chromatographs; upon elution, the samples are measured with the appropriate detector (_i.e._, mass spectrometer, flame ion detector, electron capture detector, nitrogen or phosphorus detector). Some modern pesticides cannot be measured with this methodology. For example, some synthetic pyrethroids and carbamates may be thermally unstable, not absorbed, or not separated sufficiently in a gas chromatograph.

The major requirement for monitoring low pesticides exposures is the ability to sample with the precision and accuracy needed for regulatory purposes. While technology is available to absorb, elute, and measure some of the pesticides now in use, no field-tested, quantitatively valid method is available for testing for many others. Such methods are needed, with known precision and accuracy, to establish exposure measurement guidelines based on field monitoring (i.e., sampling and analysis).

EPA's Non-Occupational Pesticide Exposure Study (NOPES), which is the first attempt to develop a methodology for measuring the exposures of the population to pesticides and seek to relate these exposures to actual pesticide use patterns. NOPES applies the TEAM approach to the problem of measuring pesticide exposures: (1) a representative random sample of the population is drawn and (2) exposures are measured through all relevant types of exposure (personal air, food, drinking water, and skin). Food exposures in NOPES will be estimated using food intake diaries and market basket surveys; all other routes of exposure (skin, air, and water) will be measured directly. This multi-season study will measure exposures in two cities, using newly developed personal monitors based on polyurethane foam techniques to obtain 24-hour data, both indoors and outdoors. NOPES will identify key independent variables that explain the variability of pesticide exposure within the sample population. The study design will test hypotheses involving seasonal variations, person-to-person variations, and home temporal variations. Many new findings are expected regarding the levels of exposures of the general population, and the causes.

RADON

In recent years, researchers have investigated sources of indoor radon, monitoring devices, factors affecting indoor concentrations, behavior of radon daughters, and development of control techniques.

Radon arises from trace concentrations of radium in the earth's crust. The primary sources of indoor radon include soil gas, building materials, and tap water. Nazaroff and Nero (1984) suggest that the infiltration of soil gas directly into single-family homes is the largest contributor to indoor radon levels. They also indicate that key factors affecting radon transport from soil are radon production in soil, flow-induction mechanisms, soil permeability, and building substructure type. However, Nero _et_ _al_. (1985b) also notes that homes served by private wells or small public systems with short storage times stand a much greater chance of increased radon levels in tap water. In large buildings (_e.g._, apartments, offices), building materials and outdoor air are the main sources of indoor radon.

Measuring indoor radon concentrations requires special equipment. The two most popular, commercially available detectors are the "charcoal canister" and the "alpha track detector." Both are placed inside for a specified time and then sent to a laboratory for analysis.

Several factors may exacerbate indoor radon levels. Fleischer _et_ _al_. (1982) found airtight homes to have three times the radon levels of conventional homes. In addition, radon may be introduced by modern construction methods. Moschandreas _et_ _al_. (1981) observed that in homes where radon levels were above recommended health concentrations, increasing the mechanical ventilation reduced those levels to within the recommended range. Wyndham _et_ _al_. (1978) studied the effects of normal home ventilation methods on radon, radon progeny, and working levels and found that decreases in radon corresponded to estimated increases in house ventilation rates.

Several recent advances have helped control indoor radon. In particular, the pressure-driven flow of soil gas into houses through their understructures can be controlled. Recent work has focused on better use of barriers, sealants, and construction techniques (Nazaroff and Nero _et al_. 1984). Other techniques, which are designed to flush radon gas from the soils beneath foundations, are also effective.

Indoor radon decreases with increased mechanical ventilation. Hess _et al_. (1985) similarly found that homes with low infiltration rates had average radon levels of 3.5 times that found in drafty homes. Air-cleaning systems that use air filtration or electrostatic precipitation have also been studied. However, because their effect on the actual radon dose to the lung is unclear, air-cleaning techniques are less desirable control methods. Source reduction or increased ventilation are better for reducing indoor concentrations (Nero, 1985a).

The human health effects from exposure to radon are currently receiving significant attention. Inhaling radon decay products results in an alpha dose to the critical cells of the respiratory tract. This dose has been shown to produce lung cancer in miners. The discovery of significant exposures to indoor radon has led to estimating lifetime risk of lung cancer per unit of exposure. Nero _et al_. (1986) note that available data suggest that a 1.5 picocuries/liter (pCi/L) average contributes about 0.3 percent to the lifetime risk of lung cancer and that, in the million homes with highest radon levels, long term occupants suffer an added lifetime risk greater than and or equal to 2 percent. This latter value was derived from the existing miner mortality studies through risk projection models. At issue is whether the results from miner studies can be used to estimate risks at somewhat lower exposure levels, different population mixes, and settings. Lowder (1985) states that current estimates of radon exposure to the general public and the consequent risk indicate that about 10 percent of nonsmoking-related lung cancers may be produced by radon.

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APPENDIX

Bibliographic Literature Information Systems (BLIS) an Alphabetical Listing of 788 Abstracts to February 1987

DATE: 08-24-1987 TIME: 14:28:41

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BIBLIOGRAPHIC LITERATURE INFORMATION SYSTEM (BLIS)

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0733
Abu-Jarad, F., Sithamparanadarajah, R., Thompson, J.M., and Fremlin, J.H. (1982) "Comparisons of various techniques for measuring natural ventilation in rooms", Phys. Med. Biol., 27(11):1393-1400.

KEYWORD: ventilation, monitor, temperature, laboratory, foreign, freon, halocarbon, methodology, Britain

Various tracer gases were released into a room and the rate of decrease of their concentrations was used as a measure of the natural ventilation rate. Three instruments--automated gas chromatograph, gas sensor (for combustible gas), and Geiger-Muller counter--gave similar results. Complete mixing of all the tracers with room air required at least 20 minutes. The organohalogenated gases affected the results of the gas sensor because they were strongly adsorbed on its detector surface. Despite stratification of both tracer gas concentration and air temperature, the natural ventilation rate was not significantly affected.

0735
Abu-Jarad, F., Wilson, C.K., and Fremlin, J.H. (1981) "The registration of the alpha-particles from polonium isotopes plated-out on the surface of the plastic detectors LR-115 and CR-39", Nucl. Tracks, 5(3):285-290.

KEYWORD: radon, laboratory,methodology,radiation,design, monitor, track-etching, foreign, Britain

LR-115 and CR-39 plastic detectors were used in a laboratory setting to measure the plate-out of radon daughters (8Po-218 and 2Po-214) on their surfaces. Measurements were made by coating both detector surfaces with fresh CR-39 after completing their initial exposure to radon activity. The plated-out daughters continued to decay for about 4 hours after completing exposure and this was recorded by the CR-39 coating. Two different experiments were used to study plate-out desiccator and fan experiment. The effect of the plate-out increased the number of tracks on CR-39 while not affecting the LR-115, since LR-115 cannot record alpha-particles with the full emission energy.

Plate-out can cause over-estimation of radon concentration by several times when using CR-39.

0008
Abu-Jarad, F., and Al-Jarallah, M.I. (1986) "Radon in Saudi homes", Radiat. Prot. Dosim, 14(3):243-249.

KEYWORD: field, home,activity,outdoor,ventilation,weather,source, QA, methodology, exposure, radon, foreign, Saudi Arabia

In a survey of 400 houses in Saudi Arabia, 637 passive dosimeters measured radon concentrations from 0.13 to 0.98 picoCuries/Liter (pC/L) with a mean of 0.43 pC/L. Concentrations in unoccupied houses in the same area were twice as high. The radon daughter concentration measured in 17 unoccupied houses with a Working Level (WL) monitor ranged from 0.00135 to 0.024 WL with a mean of 0.0069 WL. The average exhalation rate measured in 37 houses by 95 passive detectors in cans sealed to the walls averaged 0.56 pC/square meter/hour. This survey, the first of its kind in Saudi Arabia, a hot climate, is compared to similar studies in cold climates.

0158
Abu-Jarad, F., and Fremlin, J.H. (1982) "The activity of radon daughters in high-rise buildings and the influence of soil emanation", Environ. Int., 8(1-6):37-43.

KEYWORD: radon, field, exposure, source, ventilation, foreign, Britain

Concentrations of radon daughters were measured in similar rooms in two high-rise buildings in Birmingham, England. The geometrical means for 40 measurements, including the basement results, were 0.90 milli Working Levels (mWL) and 1.00 mWL excluding basement results. Both were less than the mean of 2.0 mWL for 65 measurements in typical houses in the same city. The frequency distribution of these measurements was lognormal. The concentrations did not depend on the distance from ground level but may have depended on the ventilation rate of the room examined. The concentration of radon daughters in rooms above the first floor in the two high-rise buildings tended to vary inversely with the rooms' ventilation rates.

0734
Abu-Jarad, F. (1982) "Variation in long-term radon and daughters concentration with position inside a room", Radiat. Prot. Dosim., 3(4):227-231.

KEYWORD: monitor,radon,radiation,field,home,ventilation,exposure, track-etching, foreign, freon, Britain, halocarbon

Bare plastic nuclear track detectors were used in similar conditions to record alpha-particles from radon and its daughters in more than 100 U.K. houses. The LR-115 was more convenient than the CR-39 because of its energy-discriminating properties. The long-term radon and daughter concentration in air varied when both types of detectors were placed at different positions in the same room. Concentration of tracer gases at different positions in a room also varied, as observed by measuring ventilation using gas chromotography. The significance of these variations for exposure assessment is discussed.

0751
Abu-Jarad, F., and Fremlin, J.H. (1982) "The effect of a fan in reducing the concentration of the radon daughters inside a room by plate-out to the surface of the wall using plastic alpha-detectors", Health Phys. 41(1):82-85.

KEYWORD: foreign,Saudi Arabia,radon,laboratory,particulate,smoke, monitor,track-etching,ventilation,design,radium,humidity,control

Solid nuclear track detectors (CR-39) were used to study the turbulence effect in a room contaminated by a radium compound (5 picoCurie/Liter). After 143 days, the detectors showed 10 tracks/cm2/hr. To study the effect of running an air-mixing fan, several plastics were attached to the front and back of fan blades and again to the walls. The number of tracks measured on the wall detectors increased when the fans were used. The ratio between tracks on the front fan blades to those on the wall ranged from 8 to 15. The front of the fan blades usually collected more radon daughters than the backs, except for when smoke was released into the room. In this case, the smoke particles stuck to the back edges of the blades, and the activity was higher on the detectors on the backs of the fan blades. This suggests that the radon daughters were attached to the smoke particles. The authors conclude that the use of the fan increases the plate-out of radon daughters on the walls, thus possibly reducing the airbourne level. It was not clear, however, if plate-out of radon daughters on the walls would be the same as plate-out on the detectors.

0731
Abu-Jarad, F., and Fremlin, J.H. (1983) "Effect of internal wall covers on radon emanation inside houses", Health Phys., 44(3):243-248.

KEYWORD: control,monitor,track-etching, laboratory, architecture, radon, foreign, Britain

Most types of paint for the internal walls of houses reduce radon emanation from building materials. At the same time, paint increases the concentration of radon inside the material itself and the radon emanation from unpainted areas. One type of wallpaper used contains 6 ppm uranium in its decorated surfaces, and 0.3 ppm in undecorated surfaces; the coloring is the main source of uranium. Other wallpapers appear to be free from uranium. Wallpaper, gypsum, and plaster may increase the radon activity inside houses depending on their radium contents.

0736

Abu-Jarad, F., and Fremlin, J.H. (1983) "The indoor concentration of radon daughters in three different areas of the U.K.", Health Phys., 44(5):479-485.

KEYWORD: radon, foreign, monitor, track-etching, field,radiation, home, ventilation, design, seasonal, Britain

The concentrations of radon daughters were measured in 86 rooms in three areas in the United Kingdom. The geometrical means of the concentrations were Birmingham, 2.0 milliWL; Aberdeen, 6.7 milliWL; and mainland Orkneys, 2.5 milliWL. In many cases, the ground beneath the houses was an important source of radon; with good subfloor ventilation, the ground contribution was not important.

0730

Abu-Jarad, Falah, and Fremlin, J.H. (1984) "Seasonal variation of radon concentration in dwellings", Health Phys., 46(5):1126-1129.

KEYWORD: exposure,radon, track-etching, monitor,dose,field, home, microenvironment, foreign, Britain, seasonal, architecture

Long-term studies in 104 homes in Birmingham and London, England, sought to measure seasonal variation in radon and radon-daughter concentrations. The houses varied in structure and building materials. Of special interest was a comparison between inner walls made of plaster board and those made of thermalite blocks, which contain fly-ash from coal power stations. (The average concentration of uranium in British coal is 1.5 ppm.) Track-etching detectors were placed in the homes, primarily on lower floors. Average concentrations were lowest in summer and highest in winter, with average spring concentrations nearly equal to the average between summer and winter. Average concentrations were lower than those in the United States and Sweden. Levels in the London houses with thermalite blocks were similar to those in the other common structures in Birmingham with plaster board.

0392
Ackers, J.G. (1985) "A comparison of calculated indoor radiation exposure with the results of experiments", Sci. Total Environ., 45:245-250.

KEYWORD: radon, radiation, model, home, exposure, dose

A model has been developed for calculating external and internal radiation exposure in dwellings. The model consists of two adjacent rooms on top of a crawlspace. The indoor gamma ray exposure rates and radon concentrations in indoor air, predicted for a variety of conditions, are compared with observations. Predictions and observations are in reasonable agreement; for the radon concentration, the predictions may be about 40% too low.

0147
Akland, G., Hartwell, T., Zelon, H., and Rosenweig, M. (Aug. 1982) "Study of carbon monoxide exposure of residents of Washington, D.C. and Denver, Colorado", OMB Submission Package, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (115 pages). Not available from NTIS.

KEYWORD: CO,personal,exposure,statistical, method,economic,field, sample, design, methodology, EPA$

EPA submitted this document to the Office of Management and Budget as a requirement for approval to conduct a survey of personal CO exposure of residents in Washington, DC, and Denver, CO. It describes the importance of exposure data in determining health risks and the value of monitoring CO. Survey design, sample design and selection, field activities, data collection instruments, statistical methods, supporting statements, and the project budget are thoroughly explained.

0142
Akland, Gerald G. (May 1983) "Carbon monoxide exposures in Washington, D.C. and Denver, CO during the winter of 1982-3", in "Proceedings: National symposium on recent advances in pollutant monitoring of ambient air and stationary sources", EPA 600/9-84-001, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 220-233. Not available from NTIS.

KEYWORD: CO, biomonitoring, personal, exposure, monitor,sampling, methodology, microenvironment, EPA$, risk

Personal Exposure Monitors (PEMs) were used to measure CO in Washington, DC, and Denver, CO, during the winter of 1982-83.

The primary objective was to validate a methodology for measuring the distribution of CO exposures in a representative sample of an urban population so that the risk to the entire population can be estimated. The methodology for selecting the participants and measuring of CO is presented. Preliminary results indicate that the median CO value in Washington was 6 ppm, with 1% of the values exceeding 35 ppm. For Denver, the median value was 8 ppm, with 3.5% of the values exceeding 35 ppm. After further statistical analysis, the exposure data will be contrasted to estimates from fixed monitors, and an exposure profile determined for each city.

0321
Akland, G.G., Hartwell, T.D., Johnson, T.R., and Whitmore, R.W. (1985) "Measuring human exposure to carbon monoxide in Washington, D.C., and Denver, Colorado, during the winter of 1982-1983", Environ. Sci. Technol., 19(10):911-918.

KEYWORD: CO, personal,exposure, monitor, demographic,statistical, field, EPA$, microenvironment, source, distribution

A methodology for measuring the frequency distribution of CO exposure in a representative sample of an urban population has been developed and applied in two urban areas -- Washington, DC, and Denver, CO -- during the winter of 1982-83. Exposure data using personal exposure monitors (PEMs) were collected, together with activity data from a stratified probability sample of residents living in each of the two urban areas. Well established survey sampling procedures were used for selecting participants. The resulting exposure data permit estimates of CO exposure for the eligible populations of the two areas, as well as statistical comparisons between population subgroups (e.g., commuters vs. noncommuters and residents with and without gas stoves). During the study period, more than 10% of the residents in Denver and 4% of the Washington area residents were exposed to CO levels higher than 9 ppm for 8 hours (the National Ambient Air Quality Air Standard). The data also provided evidence for judging the accuracy of exposure estimates calculated from fixed-site monitoring data.

0316
Akland, Gerald, Johnson, Ted, and Hartwell, Tyler (1984) "Results of the carbon monoxide study in Washington, D.C. and Denver, Colorado, in the winter of 1982-83", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (7 pages). NTIS PB84-230069.

KEYWORD: CO, personal, exposure, monitor,EPA$,distribution,field, statistical, microenvironment, methodology

CO exposure of residents of the Washington, DC, and Denver, CO, areas was studied in the winter of 1982-83. The exposure distributions were determined by direct measurement of CO with personal exposure monitors (PEMs) through the use of statistical inference from a statistically drawn sample. The population of inference for the study was nonsmoking, noninstitutionalized adults (ages 18 to 70). Each sampled individual carried a PEM for 24 hours on one pre-scheduled day in Washington, and two consecutive days in Denver. The exposure distributions from each study area are contrasted, and factors pertaining to high exposure are discussed.

0225
Alfheim, Ingrid, and Ramdahl, Thomas (1984) "Contribution of wood combustion to indoor air pollution as measured by mutagenicity in Salmonella and polycyclic aromatic hydrocarbon concentration", Environ. Mutagen., 6(2):121-130.

KEYWORD: particulate, wood, smoke, source, smoking, health, PAH, combustion

Samples of airborne particles were collected in the same room when heated by both electricity and then wood burning. The mutagenic activity and concentration of polycyclic aromatic hydrocarbons (PAH) of these samples were compared. The effects of the heat sources were examined in the presence and absence of tobacco smoke. Burning wood in an "airtight" stove caused only minor changes in the concentration of PAH and no measurable increase of mutagenic activity of the indoor air, but both increased considerably when wood was burned in an open fireplace. However, the effects on the mutagenic activity of indoor air from wood burning in an open fireplace could still be considered moderate when compared to the effects of tobacco smoke in the room, as measured in the Salmonella assay with strain TA98 with metabolic activation.

0533
Alpen, Edward L. (1978) "Magnetic field exposure guidelines", Proceedings of the biomagnetic effects workshop, April 6-7, 1978, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720, pp. 19-26. NTIS LBL 7452.

KEYWORD: exposure, regulation, magnetic,health, research,outdoor, energy, literature

The need to establish magnetic field exposure guidelines in the reasonably near future is discussed, as well as the particular purposes for which such guidelines might be suitable. Included are recommended limits that can be used as guidelines or criteria for working environments in magnetic fields. The U.S. Department of Energy ad hoc committee was given the task of establishing guidelines for DC fields, DC field gradients, and AC fields. After interviewing people involved in new technologies that generate large magnetic fields, the committee determined that there was no significant need or reason to establish guidelines for AC fields in the immediate future. The principal problem is to work on exposure guidelines for DC fields, pulsed DC fields, and possibly DC gradients.

0083
Amemdale, Alfred A., and Hanes, N.B. (Aug. 1984) "Characterization of indoor carbon monoxide levels produced by the automobile", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 97-102. NTIS PB85-104214.

KEYWORD: CO, temperature,microenvironment,source, NIOSH,gasoline, weather, OSHA

Integrated air samples were obtained at seven small and six large service stations and two automobile dealerships. These establishments were sampled during cold and warm weather for 8 hours during each visit, and time-weighted average CO concentrations were determined. Warm weather observations did not exceed the standard of the U.S. Occupational Safety and Health Administration or the standard recommended by the National Institute for Occupational Safety and Health. Cold weather observations, however, exceeded these levels 36% and 64% of the time, respectively. Cold and warm weather CO concentrations differed significantly at the 99.99% level of probability, with values ranging from 2.2 to 21.6 ppm in warm weather. CO concentrations differed significantly at the 99.99% level of probability by establishment size, with dealerships having the highest levels, small service stations having the intermediate levels, and large service stations having the lowest levels.

0696
Andelman, Julian B. (1985) "Human exposures to volatile halogenated organic chemicals in indoor and outdoor air", Environ. Health Perspect., 62:313-318.

KEYWORD: radon, model, trichloroethylene, laboratory, halocarbon, outdoor, VOC, shower, water

Volatile halogenated organic chemicals are found in indoor and outdoor air, often at concentrations substantially above those in remote unpopulated areas. Outdoor ambient concentrations vary considerably among sampling stations throughout the United States, as well as diurnally and daily. The vapor pressures and air-water equilibrium (Henry's Law) constants of these chemicals influence considerably the likely relative human exposures for the air and water routes. Volatilization of organic chemicals and radon from indoor water use can be a substantial source of exposure. Air concentrations of trichloroethylene (TCE) in showers using TCE-contaminated ground water increased with time to as high as one-third of the occupational threshold limit values. Such volatilization and subsequent decay of TCE in air also were demonstrated in a scaled-down experimental shower. Using a simplified indoor air model and assuming complete volatilization from a full range of typical water uses within the home, calculations indicated that the expected inhalation exposures can be substantially higher than those from ingestion of these chemicals in drinking water. Although the regulation of toxic chemicals in potable water has focused traditionally on direct ingestion, the volatilization and inhalation from other much-greater indoor uses of water should be considered as well.

0720
Andelman, Julian B., Meyers, Steven M., and Wilder, Lynn C. (1986) "Volatilization of organic chemicals from indoor uses of water", Lester, J.N., Perry, R., and Sterrit, R.M., Eds., "Chemicals in the environment", Selper Ltd., London, UK, pp. 323-330.

KEYWORD: aerosol, exposure,laboratory, model, indoor, CHCl3, VOC, trichloroethylene, water, halocarbon, shower

In a model laboratory bath-shower system, volatization of choloform and trichloroethylene was found to be typically greater than 50%, but less than would be predicted from Henry's Law equilibrium. Mass transfer at the air-water interface limited volatilization. Indoor air models can predict inhalation exposures resulting from such water uses. Inhalation exposures to toxic chemicals volatizing from all indoor water uses have the potential to be larger than those from direct ingestion.

0074
Andelman, Julian B. (1985) "Inhalation exposure in the home to volatile organic contaminants of drinking water", Sci. Total Environ., 47:443-460.

KEYWORD: VOC, trichloroethylene,laboratory, water,EPA$, exposure, source, shower

Indoor air concentrations of volatilized trichloroethylene (TCE) can be substantial when TCE-contaminated water is used domestically. Using a model shower, increases in TCE water concentrations, water temperature, and drop path (time) increased the steady-state air TCE concentrations. Volatilization was incomplete, and the rates were comparable to those predicted. Indoor air models show that the potential for inhalation exposure to such chemicals is much greater than that of direct ingestion. This should be considered in developing regulations to limit adverse health impacts from contaminants of potable water.

0579

Andelman, Julian B., Couch, Amy, and Thurston, William W. (1986) "Inhalation exposures in indoor air to trichloroethylene from shower water", Kopfler, F. and Craun, G., Eds., "Environmental epidemiology", Lewis Publishers, Inc. P.O. Drawer 519, Chelsea, MI 48118, pp. 201-213.

KEYWORD: aerosol, exposure, laboratory, model, shower, solvent, trichloroethylene, water

In a laboratory bath-shower system, 43-67% of the trichloroethylene (TCE) present at room temperature volatilized, substantially less than would be predicted from Henry's law of equilibrium (91%). Mass transfer at the air-water interface limited volatilization. Indoor air models can predict inhalation exposures resulting from shower water. TCE in air increased approximately linearly with time during the first 5 to 15 minutes (the approximate time of actual domestic use). Consequently, total exposure increases exponentially, suggesting that limiting shower time can substantially reduce the user's inhalation exposure. Other calculations indicate that inhalation exposures to TCE volatizing from all indoor water uses have the potential to be larger than those from direct ingestion.

0483

Andersen, I., Lundquist, G.R., and Molhave, L. (1975) "Indoor air pollution due to chipboard used as a construction material", Atmos. Environ., 9:1121-1127.

KEYWORD: humidity, monitoring, CH2O, model, foreign, source,home, laboratory, temperature, ventilation, architecture, Denmark

Chipboard (particle board) is a common building construction material made of wood shavings held together with a urea-formaldehyde glue. The result is that formaldehyde continuously emanates from the chipboard. In 25 rooms in 23 Danish dwellings where chipboard was used in walls, floors, and ceilings, the average formaldehyde concentration was 0.62 mg/m3 (ranging from 0.08 to 2.24), exceeding the West German threshold limit for occupational exposure (1.2 mg m/3). In all rooms, the concentration exceeded the German limit for continuous exposure in outdoor air (0.03 mg m/3). In climate chamber experiments, the equilibrium concentration of formaldehyde from chipboard was directly proportional to temperature and water vapor concentration in the air. Formaldehyde concentrations decreased sharply as ventilation rates increased. A mathematical model was established for the room air concentration of formaldehyde.

0157
Andersen, I., Seedorff, L., and Skov, A. (1982) "A strategy for reduction of toxic indoor emissions", Environ. Int., 8(1-6):11-16.

KEYWORD: asbestos,polyurethane, source,carcinogen, irritant,odor, control, method, regulation, foreign, Demark, architecture

To reduce the exposure of the population to the major groups of toxic indoor pollutants, a strategy is outlined for reducing the emission of carcinogenic substances, eye-airway irritants, and odors from building materials. It is the experience of the Danish National Inventory of Toxic Substances and Products that preventive measures in the form of either a complete removal of a substance or replacement of a toxic substance by a less-toxic substance are possible. Since 1975, asbestos has been banned in Denmark for insulation purposes, and the substitution of other materials has caused no serious technical problems. Since 1978, labeling of epoxy and polyurethane products has been mandatory in Denmark. Based on an analysis of information on the labels of these products, the authors conclude that labeling makes it possible for the consumer to select the products with the least impact on human health and comfort and, consequently, with the lowest need for ventilation. These toxicological principles should be used for the improvement of existing and future building materials.

0138
Anderson, E., Browne, N., Duletsky, S., Ramig, J., and Warn, T. (April 1985) "Development of statistical distributions of ranges of standard factors used in exposure assessments", U.S. EPA, Office of Research and Development, Washington, DC 20460 (184 pages). NTIS PB85-242667/REB.

KEYWORD: body, weight, skin, surface, activity, pattern, model, lung, ventilation, rate, exposure, statistical, analysis, EPA$

To support EPA's Exposure Assessment Guidelines, statistical distributions or ranges of values were developed for body weight, skin surface area, and lung ventilation rates. Percentile distributions of body weight were computed from the Second National Health and Nutrition Examination Survey (NHANES II) data base by variance estimation of multistage sample data using the jack-knife repeated replicate approach. Distributions of skin surface areas were similarly calculated from NHANES II height and weight data by applying regression equations that were either in the literature or were developed by multivariate analysis of available measurements. Insufficient data precluded the development of distributions of ventilation rates. Instead, minimum, maximum, and mean ventilation rates at three activity levels were calculated from available measurements. Activity pattern information is presented to permit calculation of time-weighted average pulmonary ventilation rates.

0453
Angle, C.L., Marcus, A., Cheng, I., and McIntyre, M.S. (1984) "Omaha childhood blood lead and environmental lead: a linear total exposure model", Environ. Res., 35:160-170.

KEYWORD: Pb, biomonitoring, exposure, model, water, particulate, food, TEAM, statistical, children, soil

The majority of experimental and population studies of blood lead (PbB) and environmental Pb, including the Omaha, NE, study, have used the Goldsmith-Hexter log-log or power function model. Researchers compared the log-log model and a linear model of total exposure to describe the Omaha Study of 1,074 PbBs from children, aged 1-18, years as related to Pb in air (PbA), soil (PbS), and housedust (PbHD). The data fit of the linear model was statistically equivalent to the power model, and the predicted curves were biologically more plausible. The linear model avoids the mathematical limitations of the power model, which predicts PbB zero at PbA zero. From the Omaha data, the linear model predicts that PbB increases 1.92 microgram/deciliter (ug/dl) as PbA increases 1.0 ug/m3. Because PbS and PhHD increase with PbA, however, the increases in total exposure predict a PbB increase of 4 to 5 ug/dl as PbA increases 1.0 ug/m3.

0210
Anonymous (April 28, 1986) "Concern over radon in homes triggers plan for national survey", Chem. Eng. News, pp. 19-20.

KEYWORD: radon, particulate, health, field, literature, QA, risk, assessment, methodology, exposure, EPA$

Increasing knowledge and concern over the lung cancer risk from radon exposure has prompted EPA to plan a national survey "to define the scope and magnitude of radon exposure". A small pilot study will be completed in the fall of 1986, and the main survey will begin in 1987. Highlights of the survey methodology include radon detection by track-etching, geological source prediction, and data quality assurance. This article also summarizes recent radon research findings concerning sources, radon and particle or surface interactions, and risk assessment.

0242
Anonymous - Energy Data Base Citations (Oct. 1985) "Indoor Air Pollution, November, 1984 - October, 1985", (240 pages). NTIS PB85-876820.

KEYWORD: source, radon, NO2, asbestos, CH2O, energy, particulate, CO, ventilation, literature, combustion

This bibliography contains citations concerning the types and sources of indoor air pollution, the impact of energy-efficient construction, and measures to relieve the problem. Radon and radon daughters, CO, NO2, asbestos, formaldehyde, and particulates are discussed as potential pollutants. Recirculated air, insulation material, water, and natural gas are considered potential sources of pollution. Mechanical ventilation systems with air-to-air exchangers are briefly discussed.

0529
Anonymous, (1982) "National symposium on recent advances in pollutant monitoring of ambient air and stationary sources", held at Raleigh, NC, May 4-7, 1982, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (379 pages). NTIS PB84-148345.

KEYWORD: personal, exposure, organic, particulate, sampling, VOC, methodology, monitoring, multipollutant, EPA$

The second national symposium to explore recent developments that may improve the state-of-the-art for monitoring techniques was presented by the U.S. EPA's Environmental Monitoring Systems Laboratory, May 4-7, 1982, in Raleigh, NC. This symposium is part of a continuing effort to explore recent advances in pollutant monitoring of ambient air and stationary sources. Approximately 300 engineers and scientists from industry, academia, and control agencies attended the meeting. The symposium served as a forum for exchange of ideas and information. The presentations addressed both emission monitoring and ambient air monitoring and included presentations on gaseous organics, particulate pollutants, and personal monitoring. Also presented were findings relative to sampling and analytical methods as well as to a broad spectrum of organic chemicals in outdoor and indoor air. This publication is intended for those interested in air monitoring and who were unable to attend the symposium. This report includes only those papers submitted voluntarily by speakers. An agenda is included listing all the speakers who participated in the symposium.

0513
Anonymous, (1984) "Formaldehyde levels in mobile homes", U.S. Department of Housing and Urban Development, Washington, DC 20410 (40 pages). NTIS PB85-126571.

KEYWORD: CH2O, temperature, control, home, ventilation, field, exposure

A series of experiments tested the effectiveness of various methods for reducing formaldehyde concentrations in a mobile home. The methods used were (1) normal furnace operation under thermostatic control, (2) continuous furnace blower operation, (3) continuous operation of the kitchen exhaust fan, and (4) use of a furnace-modification kit that introduced fresh air from the ceiling plenum (which is vented to the outside) to the blower intake. Identical tests were performed with two types of furnaces. These furnace-modification kits reduced formaldehyde to background levels within 4 hours or less on both types of furnaces. Both furnaces produced essentially similar levels in the mobile home tested with or without their modifications.

0222
Anonymous. (1984) "Indoor air and human health: major indoor air pollutants and their health implications", Oak Ridge National Laboratory, Oak Ridge, TN 37831 (45 pages). NTIS DE85 001081/XAB.

KEYWORD: literature, health, radon, smoking, combustion, organic, microorganism

This publication is a collection of abstracts of papers presented at the Indoor Air and Human Health symposium. Session titles include: radon, microorganisms, passive cigarette smoke, combustion products, organics, and panel and audience discussion.

0757
Aurand, K., Drews, M., Seifert, B. (1983) "A passive sampler for the determination of the heavy metal burden of indoor environments", Environ. Technol. Lett., 4:433-440.

KEYWORD: monitor, Pb, Cd, activity, field, laboratory, home, QA, sampling, exposure, outdoor, foreign, West Germany

A polystyrene cup filled with 120 ml of water served as a simple and inexpenive passive sampler for heavy metals in the indoor environment. The sampler's data quality potential was evaluated using Pb and Cd. After exposure for 2 weeks the cups were sealed with polyethylene lids and analyzed by atomic adsorption spectrometry. First results of two surveys in homes in two areas of differing ambient levels show that the sampler is effective for large scale screening studies and for comprehensive studies of individual homes. The sampler's precision is good enough to detect variations in ambient conditions, ventilation rates, and residents' activities.

0750
Aurand, K., Seifert B., and Wegner, J., Eds. (1982) "Luftqualitat in innenraumen", Herstellung: Westkreuz-Druckerei Berlin/Bonn, 1000 Berlin 49 (450 pages).

KEYWORD: foreign, exposure, literature, risk, source, health, multipollutant, combustion, regulation, West Germany

On October 1 and 2, 1981, a symposium on "Indoor Air Quality" was organized by the Institute for Water, Soil and Air Hygiene of the Federal Health Office, Federal Republic of Germany. The aim of the symposium was to give an overview of the present knowledge about the quality and quantity of substances in the indoor environment. The emissions of pollutants by people and by various other sources (e.g. building materials, gas appliances, paints, and household products) were discussed, as were the problems of biological contaminants, of setting health standards for indoor air, and of the evaluation of results as they relate to human health. The present volume contains the papers presented at the symposium (some of which have been greatly enlarged by the authors for publication), as well as discussions among a number of the 250 participants. Many of these papers are cited individually in BLIS.

0432
Bach, W., and Lennon, K. (1972) "Air pollution and health at Ala Moana shopping center in Honolulu", Hawaii Med. J., 31:104-113.

KEYWORD: CO, particulate, source,field,vehicle, health, exposure, aerosol, biomonitoring

In November 1970, CO suspended particulate matter was measured at the Ala Moana Shopping Center in Honolulu, HI. During the evening peak shopping hours, automobile exhausts raised the pollution level to 47 ppm of CO and 280 ug/m3 of suspended particulates. These values are equivalent to polluted mainland city conditions. The symptoms of increased levels of carboxyhemoglobin in the blood in different groups of people and the potential adverse health effects are discussed. The toxic effects of aerosol inhalation, which may lead to pneumoconiosis are presented. Ways are suggested for avoiding excessive exposure to harmful substances.

0722
Baretta, E.D., Stewart, R.D., Graff, S.A., and Donahoo, K.K. (1978) "Methods developed for the mass sampling analysis of CO and carboxyhemoglobin in man", Am. Ind. Hyg. Assoc. J., 59:202-209.

KEYWORD: CO, biomonitoring, statistical, dose, exposure, design, methodology, laboratory

Gas chromatography was used to measure CO in air and also as an indirect means of determining the percent of carboxy hemoglobin (COHb) in blood. The blood was then used to calibrate four CO-Oximeters used in a survey of average COHb levels in various segments of the U.S. population. Mean differences, both between the two methods of analysis and between pairs of CO-Oximeters, were less than 0.1% COHb saturation. COHb values obtained on consecutive days using one CO-Oximeter were repeatable within a standard deviation plus or minus 0.13% COHb.

0590
Bates, David V. (1985) "Combustion products: overview", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds. "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 259-260.

KEYWORD: NOx, NO2, demographic, health, epidemiology, literature, combustion, children, lung

Much evidence suggests that children may have an increased incidence of respiratory infections if they are exposed to NOx in the home. This paper is designed to (1) explore the strengths of that epidemiological data, (2) answer the question of whether the consequences of NOx on pulmonary function are irreversible, (3) explore mechanisms whereby NOx may predispose one to infections, (4) relate experimental exposure data to probable levels in the home, and (5) illustrate what is known about the irreversibility of bronchiolitis, both experimental and clinical.

0597
Bates, David V. (1985) "Indoor air and human health--summary and conclusions", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O.

Drawer 519, Chelsea, MI 48118, pp. 417-421.

KEYWORD: personal,exposure,health, methodology, research, source, literature, epidemiology, multipollutant, monitoring

The body of knowledge about indoor air pollution and human health is now large enough for synthesis of the available data. Generally, chronic low-level exposures and their effects are being studied. Sorting out the analytical problems, chemical interferences, synergisms, and confounding socioeconomic and medical problems will take many years of careful and frustrating work. Strict proof of health effects caused by many of the pollutants is a distant goal. However, for some problems, solutions are already apparent. For example, radon exposure can be prevented architecturally and preventing cigarette smoke exposure requires modification of human behavior.

0393
Battaglia, A., Bazzano, E., and Bonfanti, G. (1985) "Indoor dose in Milano (Italy)", Sci. Total Environ., 45:365-371.

KEYWORD: radon, radiation, home, exposure, dose, foreign, source, Italy, architecture

This work, which is related to the problem of more carefully evaluating population exposure to natural radiation, was part of the assessment of indoor exposure in Italy. A large number of studies have shown that different building materials and techniques lead to different exposures. In Milano, the materials can be different in kind (bricks, concrete, gypsum by-products, tile-stone, paving-tile, etc.) and origin (national and foreign). For this reason, investigations in Milano complement investigations in other European countries. A large number of dwellings in Milano were investigated to evaluate the external gamma ray exposure rate; indoor radon concentrations were measured in some dwellings.

0608
Bayer, Charlene W., and Black, Marilyn S. (1986) "Passive smoking: survey analysis of office smoking areas versus climatic chamber studies", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 25-35. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: smoking, exposure, field, laboratory, nicotine, source, VOC, metal, sampling, office, halocarbon, hydrocarbon

The extent of involuntary exposure to environmental tobacco smoke (ETS) is difficult to establish due to several factors including the complexity and variability of ETS composition, and the similarity of its constituents to those emitted from other sources of airborne contaminants. To investigate these factors, the smoking areas of several office buildings were investigated for the presence of volatile organic compounds (VOCs) that could be related only to ETS. No attempts were made to measure the amounts of ETS or relate the findings to other building factors. Tenax and Porapak Q were used to collect samples, with subsequent analysis by thermal desorption/gas chromatography/mass spectrometry. Nicotine was collected on cold Petri dishes and analyzed by gas chromatography with thermionic nitrogen-phosphorus detection. Inductively coupled plasma spectrometry was used to identify metals in the particulate portion. The compounds detected in the buildings were compared with those identified from sidestream cigarette smoke. The VOCs detected in the offices were similar and included 1,1,1-trichloroethane, toluene, xylenes, and hydrocarbons. In several smokers' offices, ppt levels of nitrogen compounds were detected that are not common to the indoor atmosphere but have been identified in cigarette smoke. These include: pyrrolidine, 2-methyl-1*H*-pyrrole, and 2-methylpropyl cyanate. Several metals, including Cd, Cr, and Ni (which are known to be present in mainstream cigarette smoke) were detected in the offices of two smokers. Additional investigations are planned to search for better methods for determining ETS. Chamber studies will closely simulate actual room conditions but eliminate other unknown indoor contaminant sources.

0662
Beall, James R., and Ulsamer, A.G. (Dec. 1981) "Toxicity of volatile organic compounds present indoors", Bull. N.Y. Acad. Med., 57(10):978-996.

KEYWORD: multipollutant,CH2O,exposure,combustion,aromatic,source, literature, health, pesticide, halocarbon, VOC, phthalate

This paper discusses the indoor sources, concentrations, and health effects of over 40 volatile organic compounds. VOCs are toxic, and their health effects have been characterized at relatively high experimental or industrial concentrations. Known effects of these compounds include tissue irritation, intoxication, nerve and organ damage, birth defects, mutations, and cancer. Few data are available on their indoor concentrations, although they are relatively low. Except for formaldehyde, little is known of the health effects of chronic exposures to indoor pollutants.

0271
Beard, J. Howard, et al. (May 1977) "The status of indoor air pollution research ", EPA-600/4-77-029, U.S. EPA, Environmental Monitoring and Support Laboratory, Research Triangle Park, NC 27711 (487 pages). Not available from NTIS.

KEYWORD: outdoor, health, methodology, ventilation, monitoring, literature, energy, EPA$

Numerous research projects have examined the occurrences of air pollution in outdoor and workplace environments. A smaller, newer body of research has examined air pollution in nonworkplace, indoor environments. A new emphasis on curbing heat loss through reduced indoor-outdoor air exchange has encouraged interest in the relation among indoor and outdoor air quality, energy conservation in buildings, and the potential for adverse health effects from indoor air pollution in nonworkplace environments. This body of research is reviewed in this report. Preparation of this report required a comprehensive survey and assessment of the state-of-the-art of indoor air pollution research, as described in published literature and unpublished ongoing research.

0544
Beck, J.V., Young, R., Hollowell, C.D., Turiel, I., and Pepper, J. (1980) "The effects of energy-efficient ventilation rates on indoor air quality at an Ohio elementary school", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (62 pages). NTIS LBL-10223.

KEYWORD: microorganism,CO2,SO2,NOx,odor,particulate,CO, aldehyde, ventilation, outdoor, exposure, energy, school

To determine the effects of energy-efficient ventilation rates on indoor air quality, the Lawrence Berkeley Laboratory measured indoor air quality at Fairmoor Elementary School in Columbus, OH. Air was monitored outdoors, as well as in two classrooms and a large multipurpose room. Tests were made at three ventilation rates. The parameters measured were outside air flow rates, odor perception, microbial burden, particulate mass, total aldehydes, CO2, CO, SO2, O3, and NOx. This report gives the results of the measurements and compares them with existing outdoor air quality standards. CO2 concentrations increased as the ventilation rate decreased, but did not exceed current standards. Odor perceptability increased slightly at the lowest ventilation rate. Other pollutants showed very low concentrations, which did not change with reductions in ventilation rate. This study indicates that it would be possible to achieve moderate energy savings at the Fairmoor school while maintaining acceptable indoor air quality.

0394
Becker, Albert P. III, and Lachajczyk, Thomas M. (Sept. 1984) "Evaluation of waterborne radon impact on indoor air quality and assessment of control options", U.S. EPA, Industrial Environmental Research Laboratory, Research Triangle Park, NC 27711 (146 pages). NTIS PB84-246404/REB.

KEYWORD: radon,literature,exposure, control, source, ventilation, statistical

The report gives results of a literature search concerning the concentration of waterborne radon (Rw) and its effect on indoor air concentration of radon (Ra). Major factors that influence Ra/Rw (including ventilation rate, water transfer efficiency, water use rates, and volume of the home) are examined. Sensitivity analyses are conducted to define mathematically a representative value for Ra/Rw (0.00007) and its reasonable bounds (0.000017 to 0.00035). The report also assesses techniques for removing radon from water or indoor air. Techniques evaluated for removing radon from water include decay, aeration, and granular-activated carbon. Techniques evaluated for removing radon and/or progeny from air include circulation, ventilation, filtration, electrostatic precipitation, charcoal adsorption, chemical reaction, and space charging. Evaluation of cost, efficiency, and practicality of each technique is provided as found in the literature reviewed.

0047
Behar, Joseph, Schuck, Edward A., Stanley, Richard E., and Morgan, George B. (1979) "Integrated exposure assessment monitoring", Environ. Sci. Technol., 13(1):34-39.

KEYWORD: multipollutant, literature, environmental, source, receptor, exposure, monitoring, epidemiology

A conceptual framework is presented for systematically collecting environmental (air, water, land, and crop) data. The objective of Integrated Exposure Assessment Monitoring (IEAM) is to provide data required for strategic control of "critical sources" of pollutants that cause major problems or threats to "critical receptors". A critical receptor is defined as that segment of the human population or of the environment that is most adversely affected by exposure to a pollutant. These ideas are intended to help coordinate efforts that involve movement of pollutants from sources to receptors through various environmental pathways.

0395

Benson, F.B., Henderson, J.J., and Caldwell, D.E. (Aug. 1972) "Indoor-outdoor air pollution relationships: a literature review", AP-112, U.S. EPA, Office of Administration, Technical Publications Branch, Research Triangle Park, NC 27711 (73 pages). Not available from NTIS.

KEYWORD: literature, outdoor, particulate, ventilation, source, exposure, microorganism

Extensive measurements have been and are being made of outdoor pollution. In contrast, very few data have been gathered on indoor pollution, especially in view of the importance of the problem. The data that are available are compiled and analyzed in this report. Based on a review of the literature, it was possible to infer relationships between indoor and outdoor pollution and to identify factors that affect these relationships. Except for bacteria and, perhaps, for fungus spores, indoor pollution levels appear to be controlled primarily by outdoor concentrations. Other factors that influence indoor pollution levels include internal activities and pollutant generation, atmospheric conditions and natural ventilation, time, location, type of building, and air conditioning and filtration systems. At present, the best available estimate of indoor concentrations of particulates and nonreactive gases can be obtained by assuming them to be equal to outdoor concentrations. Indoor concentrations of pollen and reactive gases, expressed as a percentage of outdoor concentrations, decrease with increasing outdoor concentrations. Bacterial concentrations indoors appear to be more closely related to the presence and activities of people inside than to outdoor concentrations.

0168

Berglund, B., Johansson, I., and Lindvall, T. (1982) "A longitudinal study of air contaminants in a newly built preschool", Environ. Int., 8:111-115.

KEYWORD: VOC, butanol, CH2O, toluene, pentanal, control, hexanal, ventilation, field, source, school

Air quality in a newly built preschool was investigated in a longitudinal study. Typical air contaminants emanating from building materials were determined; their variation over time (0-18 months) was measured; and the influence of the ventilation system (81% to 91% recirculation of return air) on contaminant concentrations was studied. Volatile organic compounds (VOCs) were sampled by adsorption on porous polymer, analyzed by a gas chromatography/flame ionization detection system, and identified by mass spectrometry. VOCs and CO2 accumulate in the air as it moves through the building. All the organic compounds except formaldehyde decline in concentration, mainly within the first 6 months of occupancy. Specific ventilation procedures can correct this pollution problem.

0420
Berglund, B., Johansson, I., and Lindvall, T. (1982) "The influence of ventilation on indoor/outdoor air contaminants in an office building", Environ. Int. 8:395-399.

KEYWORD: CO, CO2, NOx, VOC, field, office, energy, ventilation, exposure, CH2O, laboratory, source

A modern energy-efficient office building was studied in a series of experiments with mobile laboratories connected on-line with the building. The investigation covered measurements of inorganic air contaminants (CO, CO2, NOx). Off-line measurements were made of volatile organic contaminants. Samples were taken outdoors at street and roof levels, indoors at air intakes and outlets, and elsewhere. The building protected against street pollution, if location of the air intake and the mixing of air indoors were adequate. The number and concentrations of most air pollutants increased from the air intake along the pathway of the ventilation air. The organic compounds generally found outdoors also seemed to have indoor sources. Some aliphatic hydrocarbons (alkanes with 9 to 11 carbons) were almost exclusively found in the indoor air, probably originating from nonhuman indoor sources. Changes in recirculation of return air affected the concentration of different indoor pollutants in different ways. For CO and all organic compounds, a larger amount was transferred from the return air to supply air than predicted from the transfer of CO2 or from calculated flow rates. Saving energy by using a ventilation-by-demand principle cannot be generally recommended unless the effects of reduced ventilation on indoor air components other than CO2 have been properly considered.

0391
Berglund, B., Berglund, U., Johansson, I., and Lindvall, T. (1984) "Sampling of indoor air for sensory analysis in situ", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 417-423. NTIS PB85-104206.

KEYWORD: CH2O, VOC, design, methodology, multipollutant, odor

In indoor air quality studies, the choice of sampling sites and times is important because a building is a dynamic system. Additional concerns arise from the fact that stimulus appraisals in most sensory analyses in the field are dependent on proper dilution procedures. The study found that the sample representativity in an olfactometer for field use was good for dimethylsulfide, hydrogen sulfide, and formaldehyde, the ratio between theoretical and analyzed values being 0.94 to 1.11. The rise and fall times in the olfactometer, as well as in a mobile environmental chamber for sensory field studies, are satisfactorily short and permit the use of efficient and time-saving experimental designs for total human exposures. The performance of the sampling procedure during sensory field studies has been examined for samples of volatile organic compounds taken simultaneously on site in the building and in the exposure hood of the olfactometer. The losses in the sampling, dosing, and exposure system of the equipment are small.

0599
Berglund, B., Berglund, U., Lindvall, T., Spengler, J., and Sundell, J. (1986) "Environment International special issue on indoor air quality", Pergamon Journals, Inc., Fairview Park, Elmsford, NY 10523 (494 pages).

KEYWORD: health, exposure, outdoor, multipollutant, methodology, QA, literature, regulation, research

This special issue of Environment International contains revised versions of many papers presented at the Third International Conference on Indoor Air Quality and Climate, held in Stockholm, Sweden, in August 1984. Many newer papers are also included. The papers cover a wide range of indoor air quality issues, including analytical methodology, experimental design and statistical analysis, personal and total exposure assessment, health effects, abatement methods, and government regulations. The literature review is extensive, and future research needs are described from several viewpoints.

0187
Berglund, B., Berglund, U., Lindvall, T., and Nicander-Bredberg, H. (1982) "Olfactory and chemical characterization of indoor air, towards a psychophysical model for air quality", Environ. Int., 8:327-332.

KEYWORD: multipollutant, office, school, odor,

The relationship between the odor strength of total air samples and the odor strengths of the constituents was investigated in three field experiments in an office building and a new preschool. Between 60 and 120 chemical components were detected by gas chromatography/flame ionization detector in 66 indoor air samples. Most (81%) of the components detected were odorous, although most concentrations were low. A method of pattern analysis showed that indoor air in each building has a characteristic chemical and odor. From the odor patterns, the "odor print" of the outdoor air associated with the buildings was also recognized in the indoor air. Thus, the odor print of an air sample is different from its "chemical print". A model was found that predicts the overall odor strength of an air sample by using the number of flame-ionization-detected components most frequently reported to have a strong odor.

0237
Berglund, B., Lindvall, T., and Sundell, J., Eds. (1984) "Indoor air", Proceedings of the international conference (3rd) on indoor air quality and climate, Stockholm, August 20-24, 1984, Swedish Council for Building Research (5 volumes).

KEYWORD: multipollutant, ventilation, personal, exposure, field, risk, health

This five-volume set covers the spectrum of recent research into indoor air pollution. The titles and NTIS order numbers of the volumes are (1) Recent Advances in the Health Sciences and Technology, PB85-104180; (2) Radon, Passive Smoking, Particulates and Housing Epidemiology, PB85-104198; (3) Sensory and Hyperactivity Reactions to Sick Buildings, PB85-104206; (4) Chemical Characterization and Personal Exposure, PB85-104214; and (5) Buildings Ventilation and Indoor Climate, PB85-104222. BLIS contains abstracts of articles from each of these volumes.

0555
Bergman, H., Edling, C., and Axelson, O. (1986) "Indoor radon daughter concentrations and passive smoking", Environ. Int., 12(1-4):17-19.

KEYWORD: smoking, health, exposure, aerosol, particulate, lung, radon, risk

Radon daughter exposure is a well-known cause of lung cancer in miners. Since radon daughters are known to attach to aerosol particles, it was also of interest to study to what extent radon daughters in indoor air might attach to cigarette smoke. Experiments were undertaken which showed that moderate concentrations of radon daughters indoors could increase considerably, and even more than double, in the presence of cigarette smoke. The radon daughter levels obtained together with cigarette smoke may imply a risk of lung cancer for active and passive smokers.

0640
Berk, J.V., Hollowell, C.D., and Lin, Chin-I (1979) "Indoor air quality measurements in energy-efficient houses", Paper presented at the 72nd annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230(25 pages). NTIS LBL-8894.

KEYWORD: NO, NO2, O3, particulate, CO, outdoor, aldehyde, energy, CH2O, SO2, CO2, home, ventilation, activity

The potential impact of reduced ventilation on indoor air quality is being assessed. Three houses, designed to be energy-efficient, were monitored using a mobile laboratory. Parameters measured included infiltration rate, CO2, CO, NO2, O3, SO2, formaldehyde, total aldehydes, and particulates. Preliminary results show that, although considerable energy can be saved, indoor levels of several pollutants exceed outdoor levels. In general, however, the indoor levels of most pollutants are still within limits established by ambient air quality standards. Overall indoor air quality depends upon air exchange rates, building materials, and occupant activities.

0519
Berk, J.V., Hollowell, C.D., Lin, C., and Turiel, I. (1979) "The effect of reduced ventilation on indoor air quality and energy use in schools", U.S. Department of Energy, Paper presented at the 1979 international conference on energy use management in Los Angeles, CA (8 pages). NTIS LBL 9382.

KEYWORD: CO2, CO, O3, energy, ventilation, school, exposure, NOx, field, SO2, health, outdoor, microorganism

The air quality in an air-conditioned California high school has been measured at a variety of ventilation rates ranging from 13.3 cubic feet of outside air per minute (cfm) for each classroom occupant to approximately 1.5 cfm per occupant. The purpose of this pilot study was to determine the effect of reduced ventilation on indoor air quality and energy use. Parameters measured include outside air supply rate, the occupants' subjective perception of indoor air quality, airborne microbes, CO2, CO, NOx, SO2, and O3 in two classrooms, a hall, and outdoors. CO2 was the only parameter to show a substantial increase indoors when the ventilation rate was reduced; however, classroom levels still remained far below levels considered to be a health hazard. This study indicates that moderate energy savings are possible at Carondelet High School without significant deterioration of indoor air quality, and that substantial energy savings would be possible in a more severe climate.

0642
Berk, J.V., Hollowell, C.D., Lin, C., and Turiel, I. (1979) "The effects of energy efficient ventilation rates on indoor air quality at a California high school", LBL-9174, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (38 pages). NTIS LBL-9174.

KEYWORD: school, exposure, ventilation, sampling, monitoring,SO2, CO,CH2O,NOx,O3,CO2,radon,particulate,energy,field,weather,health

A pilot study was conducted at the Carondelet High School in California to determine the effects of reduced ventilation rates on indoor air quality. A mobile laboratory was attached to the building and was equipoped to continuously monitor infiltration, indoor temperature and humidity, weather, SO2, NO, NOx, O3, CO, CO2, radon, and particulate size distribution. Samples were collected of formaldehyde, total aldehydes, respirable and nonrespirable particulates, and bacteria. Only CO2 concentrations increased significantly when ventilation rates were decreased, and O3 levels decreased. Surveys showed no subjective increase in student discomfort. In classrooms, the outside air ventilation rate can be safely reduced to 2.5 cubic feet/minute/occupant, well below the American Society of Heating, Refrigeration, and Air Conditioning Engineers standard of 5.0. Similar future studies will focus on hospitals, dwellings, and other schools.

0641
Berk, J.V., Hollowell, C.D. Pepper, J.H., and Young, R.A. (1980) "The impact of reduced ventilation on indoor air quality in residential buildings", Paper presented at the 73rd annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages). NTIS LBL-10527.

KEYWORD: field, CH2O, CO, energy, exposure, NO2, radon, activity, indoor, ventilation, source, activity, home, health

One result of reducing ventilation to save energy is that indoor air contaminants build up and pose a health risk to occupants. Overall indoor air quality is influenced by air exchange rates, types of appliances and building materials used, and occupant activities. Of the may indoor air pollutants, four (CO and NO2 from gas appliances; formaldehye from urea-formaldehyde materials, and gas appliances; and radon from soil, building materials, and ground water) are receiving attention to assess potential health risks associated with energy conservation. Monitoring studies have demonstrated that, in some cases, these indoor-generated pollutants exceed outdoor air quality standards in energy-efficient houses having fewer than 0.5 air changes per hour. Further studies involving a broader range of infiltration rates and occupancy conditions are needed before energy-efficient infiltration standards can be set for residential buildings.

0518
Berk, J.V., Young, R.A., Brown, S.R., and Hollowell, C.D. (1981) "Impact of energy-conserving retrofits on indoor air quality in residential housing", Paper no. 81-22.1 presented at the 74th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (26 pages).

KEYWORD: CO, CO2, NO2, NO, NOx, CH2O, home, SO2, O3, ventilation, radon, energy, activity, aldehyde, exposure, particulate

The impact of energy-conservation retrofits on the air quality of residential buildings is being assessed by measuring air leakage, air-exchange rates, and indoor air pollutants before and after the retrofits. A mobile laboratory took detailed measurements of air-exchange rates and concentrations of radon, formaldehyde, total aldehydes, particulates, CO2, CO, NO2, NO, O3, and SO2 in two houses; effective leakage area measurements were made in seven others. Results from the nine houses showed that the impact of energy-conserving retrofits depends on (1) the type and extent of the retrofit, (2) the operating characteristics of the heating/cooling system, and (3) the activities of the occupants.

0305
Bernstein, R.S., Falk, H., Turner, D.R., and Melius, J.M. (1984) "Nonoccupational exposures to indoor air pollutants: a survey of state programs and practices", Am. J. Public Health, 74(9):1020-1023.

KEYWORD: CH2O, CO, CO2, NO2, radon, asbestos, smoking, pesticide, methodology, regulation

In 1982, 32 States (63%) had either a program or person(s) responsible for evaluating exposures to one or more non-occupational indoor air pollutants (NIAPs). Only four States (8%) had existing or proposed NIAP exposure standards. Twenty-nine (57%) of the States had a program to evaluate non-occupational exposures to formaldehyde, but these varied widely. Coordinated, consistent approaches are needed to define and control emerging environmental public health problems such as indoor air pollution.

0361
Berwick, M., Zagraniski, R., Leaderer, B.P., and Stolwijk, J.A.J. (1984) "Respiratory illness in children exposed to unvented combustion sources", Berglund, B., Lindvall, T., and Sundell, J.,

Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 255-260. NTIS PB85-104198.

KEYWORD: NO2, home, exposure, health, design, source, combustion, kerosene, QA, demographic, children, lung

Using a staged design of air quality monitoring, researchers followed 174 families using unvented kerosene heaters and 173 families without heaters for 3 months to evaluate the association between NO2 exposure and acute respiratory illness rates. Environmental and health data were obtained through personal interviews, bi-weekly telephone interviews, tax assessor records, and 2-week integrated NO2 measurements in 303 residences. The study followed 121 children under age 13, 59 living in homes with kerosene heaters and a control group of 62 living in homes without. Initial analyses indicate that exposed children have significantly more days of acute respiratory illness than the control group. Limitations are imposed by sample size and by possible selection bias.

0492
Biller, W.F., Thomas, H.C., Jr., Stoekenius, T.E., and Paul, R.A. (1984) "Estimation of short-term sulfur dioxide population exposures", Paper no. 84-109.7, presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (18 pages).

KEYWORD: exposure, health, distribution, model, source, activity, SO2, statistical, EPA$, industrial

A population exposure analysis methodology was developed to determine how often exercising asthmatics might be exposed to concentrations of SO2 equal to or greater than 0.5 ppm. Analyses of both ambient and modeled air quality data showed 1-hour SO2 concentrations of 0.5 to 0.75 ppm occurring near major point sources. This methodology uses modeled data near three utility power plants. The exposure calculations used a modified version of EPA's NAAQS Exposure Model (NEM). The methodology expresses the results in a probability-weighted distribution and estimates the expected number of exposures to SO2.

0488
Biller, William F., et al. (1981) "A general model for estimating exposure associated with alternative NAAQS", Paper no. 81-18.4, presented at the 74th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (25 pages).

KEYWORD: NO2, SO2, particulate, model, EPA$, outdoor, personal, NEM, exposure, microenvironment

EPA is responsible for establishing National Ambient Air Quality Standards (NAAQS) and for periodically reviewing these standards to determine their appropriateness. This paper presents a general NAAQS exposure model (NEM) for estimating population exposures associated with various possible air quality standards and also presents some sample results from a specific application of the model. NEM employs Monte Carlo techniques to simulate (1) the temporal and spatial behavior of pollutant concentrations and (2) the activities of people with regard to time, place, and exercise level. NEM has been applied to NO2, SO2, and particulates. NEM uses output from air monitoring networks and estimates actual personal exposure by transforming ambient concentrations of pollutants to concentrations that occur within an exhaustive set of microenvironments.

0103
Billick, I., Johnson, D., Moschandreas, D., and Relwani, S. (Aug. 1984) "An investigation of operational factors that influence emission rates from gas appliances", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 181-188. NTIS PB85-104214.

KEYWORD: NO, NO2, CO, ventilation, combustion, appliance, source, laboratory

This paper describes the impact of various operational factors on emission rates of trace combustion products from unvented gas appliances. The impact of the following factors on indoor NO, NO2, and CO emission rates was evaluated under controlled conditions in an environmental chamber: (1) appliance type and/or design, (2) primary aeration level, (3) fuel input rate, (4) time dependence of emission rates, and (5) presence of absorbing surfaces. Results indicate that several of these factors have an impact on exposure to indoor contaminant levels similar in magnitude to the impact of the air exchange rate of indoor environments.

0638
Billings, C.E., Baker, J.H., and Helsing, K.J. (1985) "Report on medical, epidemiological, and environmental investigations of indoor air quality at Northern Middle School, 701 Northern Avenue, Hagerstown, Maryland 21740", Johns Hopkins University School of Hygiene and Public Health, Division of Environmental Health Engineering, 615 N. Wolfe St., Baltimore, MD 21205 (28 pages).

KEYWORD: exposure, sampling, school, outdoor, CO, SO2, CH2O, VOC, ventilation, health, epidemiology, demographic

From January through August 1985, a team studied the Northern Middle School in Hagerstown, MD. Studies were designed to investigate continuing faculty reports of irritation, headaches, fatigue, and poor air quality since the school opened in 1980. A medical evaluation of 62 of 65 faculty and staff members included medical history, physical examination, and clinical tests. Epidemiologic studies of students were performed using attendance, health, and academic achievement records, plus two questionnaires about symptoms experienced. Headache, fatigue, and eye/throat irritation were prevalent in the faculty, staff, and students. Pulmonary function tests and laboratory analyses of body fluid samples gave normal results. Outdoor and indoor air samples were obtained for CO and SO2 by continuous monitors during February and March. To access occupant exposures, 17 area samples for formaldehyde and organic vapors were obtained. No gas concentrations exceeded Federal or State exposure standards. Room inlet air mixing was evaluated using tracer gas dilution studies and was poor. Improved ventilation and continued sampling are recommended.

0192
Billings, Charles E., and Vanderslice, Sandra F. (1982) "Methods for control of indoor air quality", Environ. Int., 8:497-504.

KEYWORD: literature, ventilation, model, control,source, outdoor, exposure, QA, energy

This report presents results of a review of available methods for control of environmental hazards applied to indoor air pollutants. Indoor air pollution originates from transport of ambient outdoor air contaminants into occupied spaces by natural infiltration, ventilation, or by mechanical ventilation using outdoor makeup air, plus contributions from indoor emission sources. When air exchange with the external ambient environment is reduced to conserve energy, contributions from indoor emission sources may dominate indoor air pollutant levels. The performance characteristics of ventilation systems and of air-cleaning devices used in mixed modes for ventilation of occupied spaces are described. Models for predicting effectiveness of several alternative modes are reviewed, with field trial validation results cited where available. Results of previous confined-space studies are briefly reviewed as points of departure for considering necessary air quality, ventilation, and air-cleaning problems.

0055
Binder, R.E., Mitchell, C.A., Hosein, H.R., and Bouhuys, A. (1976) "Importance of the indoor environment in air pollution

exposure", Arch. Environ. Health, 31:277-279.

KEYWORD: particulate, SO2, NO2, field, personal,exposure,smoking, children, demographic

A portable personal air pollution sampler was used to measure the exposures of 20 children to respirable particulates, SO2, and NO2 over a 24-hour period. Particulate exposures were significantly higher among children who lived with one or more smokers, exceeding the primary National Ambient Air Quality Standard in 19 of the 20 subjects. To a large extent, an individual's respirable particulate load appears to be largely determined by exposure to indoor rather than outdoor pollutants.

0698
Bisgaard, P., Molhave, L., Rietz B., and Wilhardt, P. (1984) "A method for personal sampling and analysis of nanogram amounts of formaldehyde in air", Am. Ind. Hyg. Assoc. J., 45(6):425-429.

KEYWORD: sampling, monitor, CH2O, humidity, temperature,acrolein, aldehyde, industrial, method, foreign, laboratory, Denmark

Analysis of small amounts of formaldehyde in air involved testing a solid sampler on a standard atmosphere 0.2 to 0.8 mg/m3 dry air. A single 340 - mg sorbent section without drying sections had a capacity of 16 ug formaldehyde in dry air and 3 ug at 70% relative humidity, 23 degrees C. For fluorimetric analysis, precision was better than 6% for samples of 300, 600, and 1200 ng formaldehyde, and accuracy better than 10%. For colorimetric analysis, the precision was 12% for a 300 ng formaldehyde and 2% for 600 and 1200 ng, and accuracy was better than 7%. Both analyses were accurate and sensitive methods for determination of low formaldehyde concentrations. The accuracy remains to be verified when measurements last more than 15 minutes and a dessicant is used. Positive interference from acrolein (5-7% when equimolar amounts are present) was found; no other aldehydes interfered. The experiments occurred at the University of Arhus, and the Danish National Institute of Occupational Health, Denmark.

0067
Bock, Fred G. (1982) "Nonsmokers and cigarette smoke: a modified perception of risk", Science, 215:197.

KEYWORD: particulate, risk, assessment, exposure, health,smoking, literature

A technical comment on an earlier paper discusses the relative merits of using low-tar cigarette equivalents as surrogates for nonsmokers' exposures to indoor air pollution from tobacco smoke. The commenter suggests that using low-tar cigarettes as surrogates flaws an otherwise interesting and useful aid for evaluating nonsmokers' exposures, since no epidemiology exists relating smokers' exposures to such recently marketed cigarettes with adverse health effects. The authors reply that they did not derive an exposure-response relationship between low-tar cigarette equivalents and nonsmokers' health, but merely used this comparison to place nonsmokers' exposure in perspective. Moreover, they add, the cloud of pollution surrounding smokers of low-tar cigarettes is not very different from that surrounding smokers of high-tar cigarettes who do not inhale, and the mortality rate of the latter is significantly elevated relative to nonsmokers.

0243
Boeniger, M. (March 1984) "Industrial hygiene survey reports", National Institutes for Occupational Safety and Health, Cincinnati, OH (20 pages). NTIS PB84-243237.

KEYWORD: industrial, exposure, methylenedianiline, ventilation

An industrial hygiene survey was conducted at the Olin Corporation, Moundsville, WV, plant in August 1983 to determine whether a health hazard existed from 4,4'-methylenedianiline (MDA) exposure. The facility employed 300 workers, most of whom were middle aged. Environmental, dermal, and breathing-zone samples were analyzed for MDA. Ventilation was measured. Dermal contact with MDA probably affected only six employees. Recommendations include improvement of exhaust ventilation and the use of personal protective equipment.

0227
Boleij, J., Lebret, E., Smit, J., Brunekreef, B., and Biersteker, K. (1982) "Innenluftverunreinigungen durch kohlenmonoxid und stickstoffoxide", (indoor air pollution by carbon monoxide and nitrogen oxides), Aurand, H.K., Seifert, B., and Wegner, J., Eds., "Luftqualitat in innenraumen". Gustav Fischervertag, Stuttgart - New York, pp. 199-208, (in English).

KEYWORD: CO, NO2, source, combustion, outdoor, home, monitoring, exposure, foreign, Netherlands, appliance

The results are reported of an exploratory survey of indoor levels of CO and NO2 from gas-fired cooking and water-heating appliances in the Dutch cities of Arnhem and Enscheda in the fall of 1980. Measurements were carried out electrochemically (Ecolyzer 2000) or with Draeger tubes for CO and with Palmes diffusion tubes (5 to 8 days' exposure) for NO2. The arithmetic mean value of the NO2 concentration in 286 homes was 118 g/m3, with a range of 35 to 472 g/m3. The corresponding figures for living rooms were 58 and 35 to 346 g/m3, respectively. Outdoor NO2 concentrations were 2 to 3 times lower than indoor concentrations.

0283
Boleij, J.S.M., Lebret, E., Hoek, F., Noy, D., and Brunekreef, B. (1986) "The use of Palmes diffusion tubes for measuring NO2 in homes", Atmos. Environ., 20(3):596-600.

KEYWORD: NO2, outdoor, laboratory, sampling, field, methodology, QA

The results of exposure chamber and field validation tests of NO2 diffusion tubes are reported. In the exposure chamber, about 50 test runs at various relative humidities were performed. The field validation consisted of comparisons between tubes and a chemiluminescence monitor in nine homes during several days in the kitchen, living room, bedroom, and outdoors. The results indicate a dependency on relative humidity, while the often-quoted accuracy of 10% for the diffusion tubes might be too optimistic for their use in homes.

0620
Bond, A.E., Thompson, V.L., Ortman, G.C., Black, F.M., and Sigsby, J.E. (1986) "Self service station vehicle refueling exposure study", Hochheiser, S. and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurment of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 458-466. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: VOC, source, outdoor, personal, exposure, gasoline, vehicle, microenvironment, sampling, laboratory, field, EPA$

A 4-day, ten-vehicle study was conducted to quantify the concentration and composition of gasoline vapor at five fixed distances from a single island refueling point during February 1985, in Raleigh, NC. Liquid and vapor grab samples were collected to identify and quantify the specific components of a commercial unleaded regular gasoline and associated refueling vapors. This study also provided information on the potential individual exposure during self-service refueling operations. Vapor samples were collected in evacuated, 6-liter, stainless steel canisters at five fixed distances from the vehicle refueling intake point. The sampling was conducted under three different wind directions relative to the vehicle intake point. Meteorological data were collected at the study site during all sampling periods. Vapor samples were analyzed by both cryogenic preconcentration direct flame ionization detection (PD-FID) and by gas chromatography/flame ionization detection (GC-FID) for total non-methane organic carbon. Analysis provided a detailed hydrocarbon profile (82 compounds) for all liquid samples and vapor samples greater than 20 ppm as carbon.

0546
Bornschein, R.L., et al. (1985) "The Cincinnati prospective study of low-level lead exposure and its effects on child development: protocol and status report", Environ. Res., 38:4-18.

KEYWORD: Pb, biomonitoring, exposure, children, sampling, health, dose, demographic, distribution

The study protocol for the Cincinnati, OH, prospective study of low-level Pb exposure and its effects on childhood development is detailed. The central issue of the study pertains to circumstances under which young children may experience adverse effects on normal neurobiologic and psychological development attributable to low-level Pb exposure. Blood Pb levels are systematically monitored from birth to age 5 years at 3-month intervals to provide a history of each subject's Pb exposure. Intellectual and behavioral development are assessed at regular intervals to document the child's cognitive and behavioral development. The project will then attempt to integrate information on exposure history, cognitive and behavioral development, and health and social functioning in order to delineate the association between the chronic low-level Pb exposure and behavioral development. A dose-response analysis will also be made seeking to relate the frequency with which effects occur to degree of Pb exposure.

0112
Bose, D. (Aug. 1984) "Preparation of low concentrations of gases without pumps -- a low-cost method for developing countries", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp 239-244.

KEYWORD: CO, energy, sampling, methodology, QA

An energy-saving, low-cost gas-dilution technique has been developed for preparing calibration gases, standardizing measurements at ppm levels, assessing the toxicologic and other effects of polluted air, and conducting other envirochemical studies in developing countries. This simple glass apparatus also has potential use in collecting air samples without use of a pump for transportation to analytical laboratories. Air samples containing a low level of CO have been prepared for calibration of the new technique. Pure, dry experimental gas is collected in a specially fabricated graduated microburet via a three-way stopcock, and the evacuations are done manually by liquid level differentiations. The apparatus may also be used in color comparison methods for detection of gaseous pollutants.

0384
Botzenhart, K., Altenhoff, K., and Leithold, T. (1984) "Molds in the air of greenhouse homes", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 277-282. NTIS PB85-104206.

KEYWORD: sampling, greenhouse, microorganism, particulate, field, control, source

Green plants have a favorable influence on the indoor air quality, e.g., relative humidity and dust concentration. However, plants and the soil in which they grow may increase airborne molds. Cultures obtained from various impaction samples and from soils and leaves were used to examine viable mold spores in (1) a former greenhouse used as an architect's office, (2) a private home built with an integrated live-in greenhouse, and (3) the tropical greenhouse of the local botanical garden. High concentrations of molds were found in the air of the first and second indoor greenhouse environments (6,000 culture-forming units), mostly penicillium and cladosporium species. Aspergillus fumigatus and other thermotolerant fungi were rarely isolated from air samples. They were abundant, however, in soil samples, particularly those with decomposing material such as leaves or bark.

0588
Brain, Joseph D., and Barry, Brenda E. (1985) "Biological potential and exposure-dose relationships for constituents of cigarette smoke", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 215-225.

KEYWORD: smoking, health, dose, particulate,biomonitoring,source, multipollutant, combustion, research, epidemiology, lung

Central to the issue of the potential health impact of passive cigarette smoking is an understanding of the fate of inhaled smoke. Deposition patterns of any aerosol such as passive cigarette smoke depend on the size, shape, and density of the individual particles or droplets. In particular, the description of particle diameters, preferably in terms of aerodynamic diameters, is essential. Time and concentration are important because they modify tobacco smoke through processes such as evaporation and agglomeration. Factors independent of particle size such as respiratory airway anatomy, breathing pattern, and underlying pulmonary disease also influence deposition of tobacco smoke. Lung clearance mechanisms also affect deposition. Although the amount of cigarette smoke deposited in the lungs during passive smoking is small compared to that encountered by the active smoker, large numbers of persons are involved.

0390
Breysse, Peter A. (1984) "Formaldehyde levels and accompanying symptoms associated with individuals residing in over 1000 conventional and mobile homes in the state of Washington", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 403-408. NTIS PB85-104206.

KEYWORD: CH2O, home, exposure, field, health

The Department of Environmental Health, University of Washington, along with a number of commercial laboratories, has monitored formaldehyde in more than 1,000 conventional and mobile homes. Almost without exception, requests for monitoring involved individuals who developed symptoms or whose symptoms got worse after moving into a mobile home or following application of urea-formaldehyde foam insulation. For many, symptoms continued for years despite the fact that formaldehyde levels decreased with time. Leaving the offending environment was the only solution for some individuals. The major source of formaldehyde in mobile homes was particle board, while in conventional homes it was urea-formaldehyde foam insulation. Average concentrations of formaldehyde in mobile homes were 2 to 10 times higher than concentrations in conventional homes with foam insulation. Symptoms included irritation of eyes, nose, and throat, chronic nausea, chronic headaches, difficulty in breathing, memory lapse, and behavorial changes. Most individuals experienced multiple symptoms.

0057
Brice, Robert M., and Roesler, Joseph R. (1966) "The exposure to carbon monoxide of occupants of vehicles moving in traffic", J. Air Pollut. Control Assoc., 16:597-600.

KEYWORD: CO, field, hydrocarbon, vehicle, interior, personal, exposure, microenvironment, source

CO and hydrocarbons were sampled at the operator's nose height inside vehicles moving in moderate to heavy traffic in six cities. The samples were integrated over 20 to 30 minutes by collection in Mylar bags. CO and hydrocarbons were analyzed by infrared and flame ionization, respectively, at the Continuous Air Monitoring Program (CAMP) station in each city. Detector tubes for CO were also used to determine 5-minute concentrations at suspected high points in the field. Traffic density was estimated. Three types of traffic arteries were considered: (1) heavily traveled, wide expressways, (2) main city streets with moderately rapid vehicular traffic, and (3) center-city streets with slow-moving traffic. Integrated half-hour CO concentrations obtained within the vehicles while in traffic were generally considerably higher than the concurrent concentrations measured at the CAMP sites. In-traffic CO values in all cities sampled exceeded 30 ppm in at least 10% of the integrated samples. The range of city averages was 21 to 39 ppm, and the range of individual integrated samples was 71 to 77 ppm.

0369
Broder, I., Corey, P., Cole, P., Mintz, S., Lipa, M., and Nethercott, J. (1984) "Health status of residents in homes insulated with urea formaldehyde foam compared with controls", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 23-27. NTIS PB85-104206.

KEYWORD: CH2O, health, exposure, source, control, home

Subjective and objective health variables were compared in 226 control subjects and 444 occupants of urea-formaldehyde foam insulated (UFFI) homes as part of a larger study. The UFFI homes had fractionally higher levels of formaldehyde. The UFFI subjects used significantly more medications and had higher prevalence of time lost on the job; colds; eye, nose, throat, and skin irritation; and other diverse symptoms. These complaints were mainly voiced by people planning to have their UFFI removed; for them medication usage or throat irritation correlated with total hours spent in the house. No significant associations were observed with formaldehyde levels. Also, there were no significant differences among the groups in a series of objective health tests. Thus, these initial results provide some support for a possible direct relationship between UFFI and adverse health effects.

0021
Brown, Dennis E. (Aug. 1982) "Planning and the control of indoor air pollution: a field survey of carbon monoxide levels at Ala Moana shopping center in Honolulu", Master's thesis in urban and regional planning, University of Hawaii at Manoa, Honolulu, HI 96822 (193 pages).

KEYWORD: exposure, personal, field, monitoring, source, control, CO, architecture

CO data were collected with a personal exposure monitor during 30 walking trips inside a shopping center in Honolulu between November 1981 and March 1982. Approximately 29% of sampled employees on the street level were estimated to be exposed to CO levels in excess of the 8-hour National Ambient Air Quality Standard (NAAQS) and about 2% in excess of the 1-hour NAAQS. The high levels can be traced to a semi-enclosed parking garage attached to the shopping center and the proximity of shops to slow-moving traffic. The thesis discussed potential design strategies for reducing and preventing harmful levels of CO at indirect air pollution sources such as shopping centers.

0561
Brown, L., Greene, B.M.R., Miles, J.C.H., and Wrixon, A.D. (1986) "Radon exposure of the United Kingdom population", Environ. Int., 12(1-4):45-48.

KEYWORD: radon, exposure, source, methodology, home, ventilation, architecture, foreign, Britain

The National Radiological Protection Board is surveying radon concentrations in dwellings throughout the United Kingdom, as well as factors that affect radon concentrations, such as the construction of the dwellings and the window- and door-opening habits of the occupants. Initial results indicate an average effective radon dose to the population equivalent to 570 microSieverts per year.

0207
Bruaux, P., et al. (1985) "Assessment of human exposure to lead: comparison between Belgium, Malta, Mexico and Sweden", World Health Organization, Geneva, Switzerland (57 pages).

KEYWORD: Pb ,biomonitoring, dose, water, particulate, TEAM, food, exposure, QA, foreign, Belgium, Malta, Mexico, Sweden

Lead content of blood, feces, drinking water, and local street dust was measured for 107 nonsmoking male teachers in Belgium, Malta, Mexico, and Sweden. Extended study in Malta sampled food, soil, and suspended particulates in ambient air. Oral intake seemed to be the main Pb source. Sampling, analytical, and statistical methods are discussed. Data quality and usability are well documented.

0568
Brunekreef, B., Boleij, J.S.M., Hoek, F., Lebret, E., and Noy, D. (1986) "Variation of indoor nitrogen dioxide concentrations over a one-year period", Environ. Int., 12(1-4):279-282.

KEYWORD: NO2, exposure, field, microenvironment,seasonal, health, methodology, foreign, Netherlands

In 15 homes, indoor NO2 concentrations were measured repeatedly for 1 year to obtain estimates of within-home and between-home variability. Every other week, diffusion tubes were used to obtain weekly average concentrations in the kitchen, living room, and bedroom of each home. The results indicate that, in all seasons except summer, the NO2 concentrations within locations within homes were stable and that between homes, indoor concentrations were systematically different. This information is important for evaluating health effect studies in which indoor NO2 concentrations are used as a measure of exposure.

0178
Brunekreef, B., Smit, H.A., Biersteker, K., Boleij, J.S.M., and Lebret, E. (1982) "Indoor carbon monoxide pollution in The Netherlands", Environ. Int., 8:193-196.

KEYWORD: CO, field, home, combustion, source, appliance, foreign, Netherlands

Most houses in The Netherlands are equipped with gas-fired heaters and cooking appliances. CO poisoning due to coal fires has virtually ceased to exist since coal-fired heaters were replaced by gas heaters. However, such poisonings still occur, although to a lesser extent, due to the use of instantaneous water heaters (geisers) that are gas fired. An investigation was carried out to establish the CO production potential of geisers in normal use in 254 houses. The results indicated that 17% of the geisers produced a CO level of more than 50 uL/L in the kitchens where they were located after 15 minutes of operation. Presence of a flue, burner type, and maintenance system proved to be the main controlling factors.

0238
Brunekreef, Bert, et al. (Aug. 1981) "The Arnhem lead study, I., lead uptake by 1 to 3 year old children living in the vicinity of

a secondary lead smelter in Arnhem, The Netherlands", Environ. Res., 25(2):441-456.

KEYWORD: Pb, source, particulate, biomonitoring, outdoor, soil, field, foreign, Netherlands

This epidemiological study was conducted in the vicinity of a secondary Pb smelter in Arnhem, The Netherlands. Blood Pb levels for 1- to 3-year-old children were slightly elevated. Pb in the air, dustfall, soil, street dust, house dust, and drinking water was also measured. Pb levels in garden soil and dustfall indoors and outdoors were the most useful parameters in explaining the variance in the blood Pb levels.

0244
Bruno, Ronald C. (Feb. 1983) "Sources of indoor radon in houses: a review", J. Air Pollut. Control Assoc., 33(2):105-109.

KEYWORD: radon, source, model, literature, soil

The primary sources of indoor radon are analyzed and discussed. These include soil gas, building material, and tap water. Within the framework of a simple steady-state analysis of the radon concentration in a model of a typical house, the potential contribution to indoor radon levels from each source was determined. When these results are compared with reported field studies of radon in houses, it appears that the infiltration of soil gas directly into a house is by far the largest contributor to indoor radon levels.

0605
Buchanan, James W., Li, Shutian, and Calloway, Clifton (1986) "A refinement of the potassium tracer method for residential wood smoke", Hochheiser, S. and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 748-754. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: methodology, QA, wood, home, outdoor,economic, sampling, K, laboratory, particulate, source, combustion

U.S. EPA currently uses potassium (K) as a tracer for the mass of wood smoke collected on ambient fine-particle filters. Total K is measured by x-ray fluorescence analysis, and soil potassium is estimated by assuming a value for the K/Fe ratio in soil, multiplying by the Fe present, and subtracting from total K analyzed.

In a cheaper and more reliable technique, water-soluble K is analyzed by ion chromatography. The assumption is that all fine-particle smoke, K (but very little soil K) is water-soluble. Preliminary results indicate this may be the case.

0778
Buist, Sonia, Chr. (Dec. 1983) "Report of workshop on respiratory effects of involuntary smoking: epidemiological studies", U.S. National Institutes of Health, 9000 Rockville Pike, Bethesda, MD 20842 (11 pages). Not available from NTIS.

KEYWORD: exposure, lung, smoking, health, research, statistical, risk, epidemiology, biomonitoring, ventilation, dose, methodology

This report summarizes presentations by experts in epidemiology, statistics, and pulmonary medicine on the pulmonary effects of passive smoking. While studies are in progress, the effects vary from negligible to quite small. It has not been determined, however, if a subgroup may be at risk, or if differences in data sets discussed at the workshop result from differences among population samples or methodology. A major weakness of all the data sets is a lack of proper exposure estimates. The experts recommended standardized questions to characterize indoor sources and ventilation practices. Most important is the need to develop and evaluate noninvasive biological markers of exposure.

0557
Burch, P.R.J. (1986) "Health risks of passive smoking: problems of interpretation", Environ. Int., 12(1-4):23-28.

KEYWORD: smoking, demographic, methodology, health, exposure, QA, literature, model, risk, statistical

This article is mainly a criticism of the methodology used by Repace and Lowrey in this journal's 1985 article: "A quantitative estimate of nonsmokers' lung cancer risk from passive smoking" (BLIS #86). The specific arguments are that (1) the exposure model is too anatomically, chemically, and statistically simplistic to be trusted, (2) the literature of the demographics of smoking and lung cancer contradict their model, (3) the epidemiological studies of passive smoking and lung cancer that Repace and Lowrey relied on are useless because they provide no data on actual exposures of the nonsmokers, (4) Repace and Lowrey rely on etiological studies discredited by the U.S. Surgeon General, and (5) Repace and Lowrey ignore some statistically correct studies that contradict their conclusions. Repace and Lowrey seem to have constructed their research to yield a predetermined conclusion. Repace and Lowrey rebut these arguments in BLIS #559.

0562
Burkart, Werner (1986) "An estimation of radiation exposure and risk from airtightening of homes in an Alpine area with elevated radon source strength", Environ. Int., 12(1-4):49-53.

KEYWORD: radon, source, exposure, field, risk, energy, control, ventilation, foreign, home, Switzerland

In large areas of the Swiss Alps, the high radium content of rocks and soil may produce high levels of radon in dwellings with low air-exchange rates. During the winter of 1982-83, a sample of 32 conventional homes showed an arithmetic mean average radon concentration in living quarters and cellars of 307 Becquerels per cubic meter (Bq/m3) or 8.3 picoCuries per liter (pCi/L) and in cellars of 1,410 Bq/m3 (38.1 pCi/L). Based on a matched pair analysis of single-family dwellings, researchers assumed that weatherstripping will increase the average radon level in the living quarters 50% or 155 Bq/m3 (4.2 pCi/L) in the sample studied. This increase results in an additional annual effective dose equivalent of 4.6 milliSieverts (mSv). The lower air infiltration alone leads to an additional exposure of about 0.01 mSv per kilowatt hour of energy saved per year. The estimated lung cancer risk from this exposure is orders of magnitude higher than the projected total risks from the production of a kWh in a large-scale power plant.

0678
Burton, Barbara, and Senzel, Alan (Feb. 1984) "Residential wood and coal combustion, task 3, health effects literature search", U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711 (75 pages). NTIS PB84-191584.

KEYWORD: literature,combustion, EPA$, coal, wood,outdoor, source, home, health

This report compiles titles and abstracts that are in the literature on adverse health effects due to air emissions (indoor or outdoor) from the residential combustion of coal and wood. Abstracts are presented alphabetically according to the last name of the lead author. The report's search plan included the files of the Combustion Research Branch, Industrial Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC; and Environmental Technology Division, Del Green Associates, Inc., Woodburn, OR, which recently completed a residential wood combustion study for U.S. EPA Region 10 and the State of Oregon. In addition, the on-line computer literature search, covered the following data bases: Biological Abstracts (BIOSIS, 1976+), National Technical Information Service (NTIS), and Excerpta Media (1976+).

0455
Caceres, T., Soto, H., Lissi, E., and Cisternas, R. (1983) "Indoor house pollution: appliance emissions and indoor ambient concentrations", Atmos. Environ., 17(5):1009-1013.

KEYWORD: home, NO, NO2, CH2O, combustion, source, CO, field, laboratory, exposure, kersosene, appliance

Researchers measured emission rates for CO, NO, NO2, and CH2O from several unvented gas and kerosene heaters typically used for domestic heating. The indoor pollutant concentrations generated by these emissions were evaluated and compared to the concentrations found in typical houses. Both the predicted and measured values exceeded the acceptable short-term air quality standards of most countries.

0461
Cain, William, S., et al. (1983) "Ventilation requirements in buildings, I., control of occupancy odor and tobacco smoke odor", Atmos. Environ., 17(6):1183-1197.

KEYWORD: particulate, odor, ventilation, smoking, CO, exposure, temperature, humidity, energy, laboratory

Psychophysical measurements of odor, supplemented with certain physical measurements, were taken to examine ventilation requirements during smoking and nonsmoking occupancy in an environmental chamber. Impressions of visitors (persons who inhaled air from the chamber only briefly) were compared with impressions of occupants. For nonsmoking occupancy, 47 combinations of temperature, humidity, ventilation rate, and occupancy density were examined. Odor level depended entirely on ventilation rate per person irrespective of the number of persons in the chamber. About 75% of visitors needed about 4 liters per second per person. Occupants, however, were satisfied with far less. In 38 conditions of smoking occupancy, 75% of visitors under customary conditions of occupancy needed 17.5 liters per second per person. For both smoking and nonsmoking conditions, a combination of high temperature (25.5 degrees C) and humidity (r.h. > 70%) exacerbated the odor problem. During smoking, CO rarely reached dangerous levels, but suspended particulate matter often reached levels considered unacceptable outdoors. Study results demonstrated the energy penalty incurred when ventilating for smoking occupancy.

0122
Callahan, M.A., et al. (Feb. 1985) "Handbook for performing exposure assessments (draft)", U.S. EPA, Office of Health and Environmental Assessment, Washington, DC 20460 (90 pages). Not available from NTIS.

KEYWORD: Pb, model, methodology, multipollutant, exposure, EPA$, multimedia

This handbook provides specific details of how EPA conducts exposure assessments. It provides practical guidance by presenting specific examples and detailed discussions of some key aspects. Areas addressed include an overview of available models that may be used in planning exposure assessments, guidance for designing and implementing exposure assessment monitoring programs, a listing and description of some useful data bases on the monitoring and measurement of substances in the environment, and a discussion of the uncertainties related to exposure assessments. This handbook also has a glossary of routinely used terms and provides standard factors used in calculations. Also included is an extended discussion of the EPA "Air Quality Criteria for Lead" document as an example of a multimedia, multisource exposure assessment. Since the handbook expands on the concepts of the "Exposure Assessment Guidelines", the Guidelines are included in an appendix.

0398
Castren, O., Vautilainen, A., Windquist, K., and Makelainen, I. (1985) "Studies of high indoor radon areas in Finland", Sci. Total Environ., 45:311-318.

KEYWORD: radon, field, home, exposure, source, foreign, Finland

Solid-state nuclear track detectors were used in a regional survey in Finland of radon in indoor air. The study comprises seven rural municipalities and two towns in an area of 80x50 km2 with a population of about 65,000. Measurements were made in 754 houses in 31 subareas. The highest and lowest subarea means were 1,200 Becquerels (Bq)/m3 and 95 Bq/m3, respectively. The estimated mean for the whole area was 370 Bq/m3. The concentrations 2,000 Bq/m3 and 800 Bq/m3 were exceeded in 32 and 90 houses, respectively. The present lung cancer incidence in the study area does not differ significantly from the national mean.

0491
Chan, D., and Howes, J.E. Jr. (1986) "Development of an indoor air information retrieval (IAIR) data base", Final report under

contract no. 68-02-4084, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (179 pages). Not available from NTIS.

KEYWORD: multipollutant, literature, personal, exposure, research

A computerized data base has been designed and constructed to provide assistance in identifying published indoor air quality literature. The Indoor Air Information Retrieval (IAIR) data base has been developed using dBASE III software and operates on an IBM personal computer. The data base includes bibliographic information and key words, which characterize the technical content of the article. (Key words are assigned from a comprehensive list that describes factors which influence indoor air quality.) Abstracts are not included in the data base. Currently, the IAIR data base contains 483 entries, 298 of which have been assigned key words. To make the IAIR data base more useful, additional work is required to (1) refine the data base structure, literature entry criteria, and key word list and (2) complete the entry of appropriate literature references and key words.

0612
Chan, C.C., Martin, J.W., Pond, P.J., and Williams, D.T. (1986) "Development of an adsorption/thermal desorption technique coupled with GC/MS for the monitoring of trace organic contaminants in indoor air", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 71-85. Not yet availble from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: VOC, laboratory, sampling, methodology, organic, QA, halocarbon, multipollutant,foreign,Canada

A multilayer sorbent cartridge coupled with a thermal desorption technique was used to collect and analyze both volatile and semivolatile organic compounds indoors. The sorbents were evaluated to determine their adsorption characteristics, breakthrough potential, retention of organics, and artifacts released from the adsorbents during the thermal desorption process. Recoveries and data reproducibility for desorption of most of the organics from the cartridge were satisfactory, except for a few compounds that appeared either to decompose or not to desorb very efficiently under the experimental conditions. The semivolatile compounds desorbed from sorbent cartridges and internal traps less efficiently than the volatile compounds. Limits of detection were determined for 52 compounds based on the volume sampled; most were in the ppt- or low-ppb-range.

0060
Chaney, Lucian W. (1978) "Carbon monoxide automobile emissions measured from the interior of a traveling automobile", Science, 199:1203-1204.

KEYWORD: CO, personal, exposure, monitor,microenvironment, field, vehicle, interior, source, monitoring

During a cross-country trip, the author monitored CO concentrations inside a traveling car using a sensitive instrument. Individual passing vehicles produced accurately measurable increases in CO concentration. The CO produced by individual vehicles varied by three orders of magnitude, demonstrating that a relatively small number of cars can be responsible for a higher percentage of total vehicle CO emissions.

0549
Chuang, C.C., Mack, G.A., Mondron, P.J., and Petersen, B.A. (1986) "Evaluation of sampling and analytical methodology for polynuclear aromatics in indoor air", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (91 pages). NTIS PB86-126326/AS.

KEYWORD: PAH, methodology, sampling, laboratory, field, QA, EPA$, design, microenvironment, home, literature, smoking, research

A generic sampling and analytical methodology was developed to characterize polynuclear aromatic hydrocarbon (PAH) concentrations in air in various microenvironments. These three studies were performed: evaluation of analytical methods, design of a sampling method, and design of a pilot study. Two analytical methods (high-performance liquid chromatography with ultraviolet adsorption and fluorescence detection, and gas chromatography/mass spectrometry) were evaluated to determine PAHs and their derivatives in air within microenvironments. The results showed that the preferred analytical approach was gas chromatography/positive chemical ionization mass spectrometry with data acquisition in the selected ion monitoring mode. A modified EPA high-volume sampler, consisting of a quartz fiber filter and a polyurethane foam cartridge, is proposed for use in a future experimental study. A literature review was conducted to (1) determine how much is known about the contribution of cigarette smoke to PAH levels in air within microenvironments and (2) evaluate the use of quinoline and isoquinoline as possible marker compounds for cigarette smoke. A pilot study was designed to assess PAH levels in residential air. The results of this study can then be applied to a future large-scale study to measure human exposure to airborne PAHs.

0417
Clark, C.S., et al. (1985) "Condition and type of housing as an indicator of potential environmental lead exposure and pediatric blood lead levels", Environ. Res., 38:46-53.

KEYWORD: Pb, biomonitoring, outdoor, source, water, architecture, home, children

In a prospective behavioral study of children in Cincinnati, OH, with blood Pb levels as high as 50 ug/dl, an intensive environmental survey was conducted and exterior of housing quality was determined visually. Five housing categories were defined: public housing, private housing (satisfactory, deteriorated, and dilapidated), and rehabilitated private housing. Serial blood Pb values for infants were compared to exterior housing category, which itself was compared with results of the intensive environmental survey. In this interim report on the first subset of available data, the housing categories were found to differ in paint and environment dust lead levels, with public and rehabilitated housing having lowest values. Blood Pb concentrations of children differed across housing categories as early as 6 months of age, with children residing in public housing having lowest levels, followed by those in rehabilitated housing. Housing category accounted for over one-half of the blood Pb variability in 18-month-old children.

0347
Clarkson, Michael (1984) "Indoor air quality as a part of total building performance", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 493-498. NTIS PB85-104222.

KEYWORD: office, ventilation, temperature, CO2, CO, VOC, radon, CH2O

An indoor air quality investigation of a 60,000-m2 eight-story government office building was carried out as a part of an in-depth study of the total building performance of the building. The transdisciplinary study included the following areas of building performance: lighting, acoustics, thermal comfort, ventilation, energy use, air circulation, air quality, occupant comfort, building envelope thermography, functional use, and enclosure integrity. The air quality conditions generic to large offices are presented.

0091
Clausing, P., Mak, J.K., Spengler, J.D., and Letz, R. (1986) "Personal NO2 exposures of high school students", Environ. Int., 12(1-4):413-417.

KEYWORD: NO2, combustion, personal, exposure, model, school, activity, pattern, outdoor, source, appliance

Personal NO2 exposures and/or time activity patterns were measured for 300 junior high school students in Watertown, MA. Palmes diffusion tubes were used to measure NO2 concentrations in the bedroom, living room, and kitchen for over 100 students. Indoor and personal NO2 levels were closely related to the cooking fuel used at home. The correlation between outdoor and personal NO2 levels was not significant. Stepwise multiple regression is used to fit models to estimate personal exposures. Models including indoor NO2 concentrations can explain between 60 and 90% of the variance in personal NO2 exposures. When indoor home concentrations are excluded, only about 40% of the variance is explained by cooking fuel, pilot lights, and concentration in the school.

0490
Clayton, A.C., White, S.B., and Settergren, S.K. (1985) "Carbon monoxide exposure of residents of Washington, D.C.: comparative analyses", Contract no. 68-02-3679, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (55 pages). Not Available from NTIS.

KEYWORD: CO,monitor,smoking,microenvironment, personal, exposure, home, source, combustion, outdoor, statistical, EPA$, appliance

CO data obtained by personal exposure monitor (PEM) from a sample of Washington, DC, nonsmoking, noninstitutionalized individuals between the ages of 18 and 70 in the winter of 1982-83 were analyzed to determine whether CO levels differ statistically among individuals. Specifically, comparisons were made among (1) major environments, (2) micro environments (within major environments), (3) smoker and nonsmoker groups, and (4) groups with and without an operating gas stove. Comparisons were based on PEM CO means and on PEM CO levels adjusted for ambient CO levels. The analysis found that ambient CO measurements provide only a crude measure of the background CO levels to which individuals would be exposed, even in an outdoor setting. PEM CO levels varied significantly across the four major environments with "in transit" showing the highest level and "indoors/at residence" showing the lowest level. Indoor environments appeared to have elevated levels of CO in the presence of smokers and in the presence of an operating gas stove.

0489
Clayton, A.C., Rodman, N.F., and Hartwell, T.D. (1985) "Total exposure assessment methodology (TEAM) multivariate analysis of air exposure and breath measurements", Contract no. 68-01-6826, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (53 pages). Not available from NTIS.

KEYWORD: TEAM, personal, exposure, statistical, outdoor, model, VOC, monitor, biomonitoring, EPA$, seasonal

This study uses data collected at various sites between 1981-84 as part of EPA's Total Exposure Assessment Methodology (TEAM) study. This report examines some of the multivariate structure of these data. In an attempt to explain the variation in breath, personal air, and outdoor principal component (PC) scores, analysis-of-variance models were used. The models related these PC scores to sites/seasons. Statistically significant differences were detected in sites/seasons with regard to breath, personal air exposure, and outdoor air exposure concentrations of the selected volatile organic compounds. Despite this, the percentage of total variation in such measurements attributable to sites/seasons was low (generally 10 to 15%). Further attempts to account for variation in the breath concentration data, by including personal or outdoor air measurements in the model (in the form of PC scores), increased these percentages to about 20 to 25 %.

0705
Cohen, A.F., and Cohen, B.L. (1980) "Protection from being indoors against inhalation of suspended particulate matter of outdoor origin", Atmos. Environ., 14:183-184.

KEYWORD: particulate,school, architecture, office, home, outdoor, laboratory

A method for estimating the protection from being indoors against inhalation of suspended particulate matter from outdoors was applied to a wide variety of buildings and rooms. Indoor and outdoor filter samples were analyzed by x-ray fluorescence for elements known to become airborne outdoors. The average protection factor was about 4.5 for large particles and 2.2 for submicron particles.

0375
Cohn, M.S., Ulsamer, A.G., and Preuss, P.W. (1984) "Sources contributing to formaldehyde indoor air levels", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 3, sensory

and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 133-138. NTIS PB85-104206.

KEYWORD: CH2O, source, exposure, home, humidity, architecture, temperature, seasonal

Two major sources of formaldehyde in indoor air are urea-formaldehyde foam insulation (UFFI) and pressed-wood products, including panelling, particle board, and medium-density fiberboard. The formaldehyde contribution that these products can make to air in conventional residences and mobile homes has been investigated. One of the most important factors is the age of the product; formaldehyde levels tend to decay more or less exponentially over time, with half lives in the range of from 6 months to between 4 and 6 years, depending on the product and its age. Examples of decay curves are presented. Also considered are the effects of variables, such as temperature and relative humidity, that can lead to diurnal variation of formaldehyde levels as much as 1.5-fold and seasonal variation as much as 10-fold. Ongoing research in this area is discussed.

0689
Coleman, Sheldon R. (1983) "A tube diffusion dosimeter for sulfur dioxide", Am. Ind. Hyg. Assoc. J., 44(9):631-637.

KEYWORD: SO2, methodology, personal, exposure, monitoring, QA, laboratory, monitor

A tube diffusion dosimeter for SO2 was fabricated from inexpensive, easily available materials. The design incorporates a tube diffusion element, liquid absorption reservoir, and a porous plastic mass transfer element. The dosimeter was verified by exposure chamber tests using constant and fluctuating SO2 concentrations, and tested in the field along with a bubbler method developed by the National Institute for Occupational Safety and Health for comparison. Laboratory and field tests confirmed that the dosimeter was reliable between 2.5 and 15 ppm SO2. However, to retain accuracy, exposed dosimeters must be refrigerated and analyzed within 24 hours after use.

0413
Colome, S.D., McCarthy, S.M., and Spengler, J.D. (June 1981) "Residential indoor and ambient outdoor comparison of gaseous and particulate air pollutants in two cities", Paper no. 81-573, presented at the 74th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (18 pages).

KEYWORD: SO4, NO2, outdoor, home, exposure, particulate, SO2, Al, Br, Cl, Ma, Na, V, source

The results from 1 year of air monitoring in 10 homes for 6 trace elements (aluminum, bromine, chlorine, magnesium, sodium, vanadium) and SO2, NO2, SO4, and respirable-size particles are reported for Steubenville, OH, and Portage, WI. Indoor and outdoor mean levels for all 10 air constituents are higher in the industrial city of Steubenville. Indoor levels are lower than outdoor for most air constituents in both cities, with the exception that mean levels of NO2, respirable-size particles, and chlorine in Portage are higher indoors, indicating residential sources of these constituents. The measured pollution difference for this sample of homes is smaller when the mean indoor, rather than outdoor, concentrations are compared. These findings have implications for previous and future epidemiologic studies of the effect of air pollution on human health.

0177
Colome, Steven D., Spengler, John D., and McCarthy, Sharon (1982) "Comparisons of elements and inorganic compounds inside and outside of residences", Environ. Int., 8:197-212.

KEYWORD: outdoor, SO2, NO2, SO4, particulate, Al, V, Br, Cl, Mn, Na, EPA$, home, exposure, source

The results of more than 1 year of air monitoring inside and outside of five homes in each of two communities (Steubenville, OH, and Portage, WI) are presented for SO2, NO2, mass respirable particles, SO4, Al, Br, Cl, Mn, Na, and V. Outdoor measurements across the home sites in each city are consistent with proximity to outdoor sources. In each city, the home appears to alter outdoor concentrations in several ways. Indoor levels of SO2, SO4, Mn, and V are lower than those measured outdoors. These constituents are thought generally to result from outdoor sources. The other constituents studied are at times found in excess within homes. In some cases, the source or sources of excess concentration of a particular constituent could be identified; often, however, the source could not be identified.

0048
Colwill, D.M., and Hickman, A.J. (1980) "Exposures of drivers to carbon monoxide", J. Air Pollut. Control Assoc., 30(12):1316-1319.

KEYWORD: CO, source, vehicle, interior, exposure, biomonitoring, ventilation, field, foreign, Britain

Eleven new cars were driven around a 35-kilometer route comprising heavily traveled roads in and around London, England, and the concentrations of CO inside and immediately outside the vehicles were continuously monitored. Average levels of CO inside were between 12 and 60 ppm, and these levels were between 30% and 80% of the external concentrations. The internal levels varied according to external changes, but the changes were greatly dampened by the ventilation system. Differences in internal CO levels were greater among the vehicles than among the different runs using the same vehicle and were probably due to differences in the ventilation systems. Blood carboxyhemoglobin (COHb) concentrations that would arise from the CO exposures were calculated. Published data suggest that these COHb concentrations (1.53%) might adversely affect health by impairing driving performance.

0691
Compton, J.R., Dwiggins, G.A., Feigley, C.E., and Ludwig, D.A. (1984) "The effect of square wave exposure profiles upon the performance of passive organic vapor monitoring badges", Am. Ind. Hyg. Assoc. J., 45(5):446-450.

KEYWORD: VOC, exposure, statistical, QA, laboratory, methodology, ethylbenzene, personal, monitor

Three commercial passive monitoring badges were exposed to ethylbenzene vapor in a dynamic test atmosphere characterized by well-defined square wave concentration profiles having periods of 2, 6, and 10 minutes. Concentrations fluctuated between 0 and 150 ppm, causing no significant bias in the time-weighted average concentration indicated by the badges. A slight, but statistically significant, interaction between badge type and exposure profile is attributable to random analytical error in the data provided by one badge type.

0044
Core, J.E., Cooper, J.A., and Houck, J.E. (Oct. 1982) "Residential wood combustion study, task 7, indoor air quality", U.S. EPA, Region X, Seattle, WA (159 pages). NTIS PB84-170653.

KEYWORD: particulate, PAH, smoke,field, weather, source, outdoor, combustion, wood, EPA$, appliance

Indoor exposure to particulate air pollution associated with residential wood combustion was studied in five typical Northwest homes during May 1980. Particulate mass and polynuclear aromatic hydrocarbon (PAH) species were measured in each home before and during wood appliance use. Air infiltration rates were obtained from the literature. Records of wood use and weather during the indoor sampling period were maintained. Results are compared to other indoor air pollution studies on residential wood combustion. Appliance operations, design, and maintenance are discussed.

0448
Cortese, Anthony. D., and Spengler, John D. (1976) "Ability of fixed monitoring stations to represent personal carbon monoxide exposure", J. Air Pollut. Control Assoc., 26(12):1144-1150.

KEYWORD: CO, personal, exposure, outdoor, NAAQS, biomonitoring, monitor, vehicle, interior, control

This study investigates the ability of fixed-location ambient air monitoring stations to represent accurately personal exposures to CO. The relationship between residential location, commuting transportation mode, employment location, and time-weighted average human exposure to CO in the metropolitan area was also explored. Personal exposure was measured by equipping 66 nonsmoking volunteers in the Boston, MA, area with portable CO samplers that use an electrochemical sensor. Measurements at six fixed-monitoring stations operated by the Massachusetts Bureau of Air Quality Control underestimated mean 1-hour personal exposure by a factor of 1.3 to 2.1. However, alveolar air samples showed no significant increases in blood carboxyhemoglobin levels due to commuting exposure, because only 1% of the commuting exposures approached the national ambient air quality standard (NAAQS) of 35 ppm for 1 hour. The underestimation of personal exposure by fixed stations is of public concern in cities reporting violations of the 1-hour NAAQS. Fixed-location measurements were representative of 8-hour average population exposure. Mode and route of travel were the only factors influencing commuting exposure to CO. Total travel by automobile resulted in a mean CO exposure nearly twice that of rail transit and approximately 1.6 times that of split-mode commuting. These results indicate that the most effective strategies for reducing both 1-hour and 8-hour exposures to CO are those requiring automobile emission control, system traffic flow improvement, and decreased traffic volumes.

0246
Cote, William A., Wade, W.A., and Yocum, J.E. (Sept. 1974) "A study of indoor air quality", U.S. EPA, National Environmental Research Center, Research Triangle Park, NC 27711 (294 pages). NTIS PB-238556.

KEYWORD: field, combustion, laboratory, source, home, appliance, EPA$

A 15-month indoor air quality study consisted of laboratory investigations, field studies, and an inventory of indoor sources. Tasks 1 and 2 established the emissions and effect on air quality of gas stoves and heaters both in the laboratory and in four homes. Task 3 developed information on indoor sources of air contamination in typical southern New England homes and on the effects of products and their use on indoor air quality.

0166
Coutant, R.W., Merryman, E.L., and Levy, A. (1982) "Formation of NO2 in range-top burners", Environ. Int., 8:185-192.

KEYWORD: NO, laboratory, temperature, combustion, control, NO2, methodology, source, appliance

This study examined NO and NO2 formation on range-top burners (RTB) and in diffusion flames. Composition and temperature profiles of the flames were determined. RTB flames and pilot flames displayed qualitatively similar behavior with respect to the kinds of flame regions in which relatively high NO2/NO ratios were identified. These regions consistently either had low oxygen concentrations or were flame surfaces subjected to thermal quenching. A limited series of experiments with modified burners indicated that emissions from both the RTB and pilot flames could be reduced by (1) improving primary aeration by using 50% or greater primary air and (2) using flame geometries designed to minimize flame surface, e.g., flat-flame burners or other designs having effectively fewer distinct ports. A practical implication of the study is that a burner designed with improved aeration/mixing and minimization of flame surface should emit less NO2.

0090
Coviaux, F., Mouilleseaux, A., and Festy, B. (Aug. 1984) "Air quality and biological controls of workers exposed in working premises contiguous to an urban road tunnel", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp 129-134. NTIS PB85-104214.

KEYWORD: CO, NO2, Pb, Fe, field, exposure, microenvironment, biomonitoring, ventilation, tunnel

This study evaluates the influence of an urban road tunnel on the atmosphere of contiguous working premises, plus biological monitoring of carboxyhemoglobin (COHb) in maintenance staff. Tunnel pollution and COHb concentrations are strongly correlated with the traffic intensity and influences of the tunnel service rooms.

0617
Crum, Jane M. (1986) "Source emissions database for indoor air pollution", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 128-133. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: literature,field, source,multipollutant, EPA$, sampling, methodology

A computerized data base for experimental results on indoor air pollution sources and their emission factors allows for convenient searches on such topics as indoor source, source class, and pollutant. It provides access to information such as: emission factors for air pollutants from indoor sources and conditions, sampling methods, and analytical techniques of each experiment. The abstracts and data for these experiments are scheduled to be available in mid-1986 in a dBase III version and in a Clipper-compiled version for IBM and compatible microcomputers.

0656
Dally, K.A., Hanrahan, L.P., Woodbury, M.A., and Kanarek, M.S. (1981) "Formaldehyde exposure in nonoccupational environments", Arch. Environ. Health, 36(6):277-284.

KEYWORD: CH2O,exposure,source,architecture,sampling,NIOSH,office, home,personal,statistical,wood,smoking,irritant,EPA$,health

Formaldhyde may be released from wood products and foam insulation containing urea-formaldhyde resins. From January 1978 to November 1979, the Wisconsin Division of Health investigated 100 structures after receiving complaints of health problems from occupants. The structures consisted of mobile homes, conventional homes, travel trailers, and office buildings throughout Wisconsin. Air samples were collected with personal sampling pumps (MSA model G) and stored in polyethelene bottles. Samples were analyzed by the chromotropic acid procedure. The occupants provided health information via questionnaires. Mean formaldehyde concentrations ranged from below the limit of detection to 3.68 ppm. Burning and irritated eyes, runny nose, dry or sore throat, headache, and cough were the primary symptoms reported. Statistically significant associations were seen between formaldehyde levels and age of home/building materials. Nonoccupational indoor exposure to formaldehyde is significant and may reach levels which exceed occupational exposure standards.

0622
Dave, J.M. (1984) "Studies on emissions from coal burning stoves (sigries) as used in Eastern India", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 383-387. NTIS PB85-104214.

KEYWORD: benzene, benzo-a-pyrene, CO, research, NOx, particulate, SO2, VOC, foreign, PAH, health, India, combustion, coal

Cooking stoves commonly used in eastern India are made from old metal buckets and burn bituminous coal, contributing to heavy indoor and outdoor air pollution. The study is to determine emissions from such a stove per kg of coal burned, and their effect on indoor air quality. The coal contains about 24% to 30% ash and 27% volatile matter. When burned, it contributes SO2, NOx, CO, benzo-a-pyrene (BaP) and suspended particulate matter (SPM), of which 90% to 95% is benzene soluble. The pollutants released per kg of coal were 9.89g SO2, 1.98g NOx, 118 mg SPM, 1.2g CO, and 21.3 g BaP. The air in the kitchen/hut had 882 to 1,390 ug/m3 SO2, 43 to 46 ug/m3 NOX, 78 to 157 ug/m3 SPM, and 14 to 23 ug/m3 BaP. These levels may affect the health of the exposed family. More detailed studies are recommended.

0080
Davidson, Cliff I., Osborn, J.F., and Fortmann, R.C. (Aug. 1984) "Modeling and measurement of pollutants inside houses in Pittsburgh, Pennsylvania", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp 69-74. NTIS PB85-104214.

KEYWORD: NO, NO2, CO, particulate, O3, CH2O, home, ventilation, SO2, VOC, model, source, energy, appliance

Mathematical models for predicting indoor air pollutant levels are being developed and compared with measured concentrations in residences in Pittsburgh, PA: a relatively new town house constructed along rigid energy conservation guidelines, a similar town house containing an air-to-air heat exchanger, and a 50-year-old house without weatherization. Efforts have focused primarily on the first residence. The results show that NO, NO2, and CO emitted from a gas kitchen stove are rapidly mixed throughout the first story of the town house; transport to the upstairs is slower. Concentrations of NO and CO decrease slowly with time after the stove is turned off; NO2 levels decrease much more rapidly. Measurement of emission rates from the stove and estimates of air exchange rates with sulfur hexafluoride have been used as inputs to a simple one-compartment mass balance model for predicting CO levels. Results of the modeling agree reasonably well with measured concentrations, assuming removal of CO only by exfiltration. Additional modeling and measurement efforts are underway for O3, SO2, formaldehyde, inhalable particles, and volatile organics.

0309
Davies, T.D., Ramer, B., and Kaspyzok, G. (1984) "Indoor/outdoor ozone concentrations at a contemporary art gallery", J. Air Pollut. Control Assoc., 31(2):135-137.

KEYWORD: O3,outdoor, ventilation, exposure,architecture, foreign, Britain

O3 concentrations were measured both inside and outside the Sainsbury Centre for Visual Arts, near a small city in rural eastern England, during a 3-week period in the summer. The inside concentration was typically 70% (+/- 10) of the outside concentration during the period of expected maximum outside levels. During the period of observation, the maximum outside O3 levels ranged up to 60 ppb, although some sampling at this location had previously recorded outside levels well in excess of 120 ppb. The relatively high indoor/outdoor O3 ratio is a function of the Centre's design, its internal geometry, and its ventilation system. Conventional art galleries and museums experience much lower indoor O3 exposure. The measured indoor O3 levels imply deleterious effects on the gallery exhibits, and an enhanced O3 exposure may have to be considered when designing modern galleries and museums.

0572
De Bortoli, M., et al. (1986) "Concentrations of selected organic pollutants in indoor and outdoor air in northern Italy", Environ. Int., 12(1-4):343-350.

KEYWORD: VOC, office, outdoor, foreign, methodology, particulate, source, architecture, home, ventilation, field, Italy

Volatile organic compounds (VOCs) were measured in the air of 14 homes and one small office building in northern Italy. The study consists of two parts: (1) 4- to 7-day mean values of the concentrations of 35 selected VOCs determined together with some complementary parameters in indoor and outdoor air to get an indication of the relative importance of VOC indoor pollution in this geographical area; (2) six indoor air samples have been analyzed in detail by gas chromatograpy/mass spectrometry (GC-MS) for a more complete qualitative characterization of indoor air pollution by VOC. Major results showed that concentrations of the 35 selected VOCs were nearly always higher indoors than outdoors, often by an order of magnitude. The mean concentration of total VOC was about 3 mg/m3 indoors, compared to 0.4 mg/m3 outdoors. Detailed GM-MS analyses identified a much larger number of compounds (more than 100 in two cases). Most of the identified compounds are solvent constituents, and many have also been detected in northern Europe and in the United States. This points to commonly use consumer products as major sources of VOCs rather than to building materials, which differ between geographical areas.

0053
De Bortoli, Maurizo, et al. (Aug. 1984) "Integrating 'real life' measurements of organic pollution in indoor and outdoor air of homes in northern Italy", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp 21-26. NTIS PB85-104214.

KEYWORD: multipollutant, field, home, VOC,Italy, office, foreign, outdoor

Concentrations of 33 organic compounds and of total volatile organic chemicals (VOC) have been determined in indoor and outdoor air in 14 homes and one office building in northern Italy. Mean indoor/outdoor concentration ratios ranged from 1.3 to 52. In addition, VOCs present in the air of six indoor spaces have been analyzed in detail. Between 47 and 118 organic compounds could be identified and quantified in these samples.

0532
Dellarco, Michael J. (June 1985) "Comprehensive indoor air quality research strategy, January 1, 1985", U.S. EPA, Office of Research and Development, Washington, DC 20460 (34 pages). NTIS PB85-246692/REB.

KEYWORD: field, research, source, energy, health, control, EPA$, economic, exposure, literature, multipollutant

The Interagency Committee on Indoor Air Quality (CIAQ), consisting of 16 Federal agencies, was formed in response to the growing concern of indoor air pollution. CIAQ has sought to develop a comprehensive research strategy to accomplish two aims: (1) to develop an understanding of the magnitude of the risk to human health from exposures to indoor air pollutants and the contribution of various energy conservation measures, introduction of new building materials, and consumer products; and (2) to provide technical information and guidance, including cost-effective mitigation measures, to state and local governments, the private sector, and the general public. CIAQ research strategy is comprised of six tasks: (1) identification of indoor air pollutant sources and factors affecting human exposure, (2) characterization of indoor air quality, (3) determination of the relationship between energy conservation and indoor air quality, (4) determination of the health effects of indoor air pollution, (5) determination of optimal control and mitigation techniques, and (6) development and conduct of national multipollutant field studies.

0373
Dement, J.M., Smith, N.D., Hickey, J.L.S., and Williams, T.M. (1984) "An evaluation of formaldehyde sources, exposures and possible remedial actions in two office environments", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 99-104. NTIS PB85-104206.

KEYWORD: CH2O, health, energy, control,sampling,source, exposure, ventilation, office, architecture

In response to employee complaints of upper respiratory and eye irritation, formaldehyde air sampling studies were conducted in two offices. The first study was conducted in a series of temporary modular buildings with construction similar to mobile homes. The second was in a new building designed for energy conservation. Average formaldehyde concentrations were between 0.06 and 0.23 ppm in the modular offices and 0.15 ppm in the new office building. Laboratory studies identified the major formaldehyde sources to be particle-board-containing furniture in the new office, and wall panelling and ceiling tiles in the modular offices. Formaldehyde emission rates ranged from 0.02 to 0.19 mg/m2 hour for the major formaldehyde sources. Fumigation with 1,000 ppm of ammonia for 24 hours reduced emissions by more than 70%. Increased dilution ventilation reduced ambient formaldehyde concentrations to below 0.10 ppm.

0501
Desaedeleer, Georges, and Winchester, John (1975) "Trace metal analysis of atmospheric aerosol particle size fractions in exhaled human breath", Environ. Sci. Technol., 9:971-972.

KEYWORD: Pb, Br, Cl, Ca, biomonitoring,trace,laboratory, aerosol, particulate, exposure, methodology, health

Using Proton-Induced X-ray Emission (PIXE) analysis researchers measured the particle size distribution of Pb, Br, Cl, and Ca, in aerosols exhaled by a human subject breathing typical polluted air. For all elements, apparent respiratory disposition fractions decreased from both small and large particle sizes to a minimum near 0.5 um aerodynamic equivalent diameter. Feasibility is demonstrated for direct determinations of trace element respiratory depositions in humans breathing aerosols at ambient air concentrations.

0372
DiNardi, S.R., Abromovitz, M.W., and Tartaglia, M.S. (1984) "A comparison of an automated continuous formaldehyde analyzer with passive dosimeters", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 85-88. NTIS PB85-104206.

KEYWORD: CH2O, seasonal, temperature, model,outdoor,weather,home, ventilation, energy, methodology, monitoring,sampling

A microprocessor-controlled, five-point, all-Teflon sequential air sampling system interfaced to a continuous formaldehyde analyzer was used to measure the seasonal variation of formaldehyde in a residential environment. Concurrent sampling was performed with dosimeters supplied by two manufacturers and the chromotropic acid impinger method. The integrated dosimeter concentrations of formaldehyde were compared to a time-weighted average formaldehyde concentration as reported by the automated analyzer. This study is part of a project designed to model indoor air pollution with its influencing factors, including indoor thermal comfort parameters, purchased power, ambient meteorological conditions, ambient air pollutants, and infiltration rate data.

0109
DiNardi, S.R., Ludwig, J.F., Tartaglia, M.S., and Abromovitz, M.W. (Aug. 1984) "A systems approach to the monitoring of indoor air pollutants", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp 175-180. NTIS PB85-104214.

KEYWORD: CO, CO2, home, weather, hydrocarbon, CH2O, architecture, monitoring, microenvironment

Building design and construction technology have improved in the past decade, and the concern over indoor air pollutants and their health effects has increased. A multipoint, multipollutant air sampling and analysis network was installed in a family residence in Amherst, MA, to assess the spatial and temporal variation of indoor air quality. The network includes a 10-point air sampling system interfaced to a gas chromatograph that continuously analyzes hydrocarbons, CO, and CO2, as well as sulfur hexafluoride, which is used to produce continuous infiltration analysis by the tracer dilution method. A five-point, all-Teflon sequential air sampling system is interfaced to a continuous formaldehyde analyzer. On-site ambient meteorological conditions, indoor thermal comfort parameters, and purchased power are also continuously monitored. The network is controlled by a dedicated microprocessor.

0330
Diemel, J.A.L., Brunekreef, B., Boleu, J.S.M., Biersteker, K., and Veenstra, S.J. (1981) "The Arnhem lead study, II, indoor pollution and indoor/outdoor relationships", Environ. Res., 25(2):449-456.

KEYWORD: Pb, outdoor, particulate, home, soil, foreign, exposure, source, Netherlands, field

House dust samples were taken of ambient air indoors, Pb deposition indoors, floor dust, and dust deposited on windowsills, etc. In addition, the dustiness of houses was estimated visually. Many outdoor parameters were determined, and indoor Pb pollution levels were lower than the corresponding outdoor levels. Statistical analysis showed that in Arnhem, Pb enters houses as particles that adhere to shoes, clothes, etc. Most of it originates from gardens and possibly street dirt.

0228
Dobbs, A.J., and Williams, N. (1983) "Indoor air pollution from pesticides used in wood remedial treatments", Environ. Pollut. Series B, 6:271-296.

KEYWORD: pesticide, hexachlorocyclohexane,dieldrin,exposure, PCP, foreign, Britain, wood, home

Air samples were collected from inside houses that had been given commercial treatments to combat wood-boring insects or dry rot. Concentrations of gamma-hexachlorocyclohexane (gamma-HCH), dieldrin, and pentachlorophenol (PCP) were measured. In the absence of guidelines for safe concentrations of these chemicals in homes, acceptable air concentrations were derived from acceptable daily intake values implemented in the United Kingdom. Assuming that inhalation is the sole route of exposure, documented dieldrin levels were above the acceptable concentrations, but the gamma-HCH and PCP levels were below these concentrations.

0332
Dockery, D.W., Spengler, J.D., Reed, M.P., and Ware, J. (1981) "Relationships among personal, indoor and outdoor NO2 measurements", Environ. Int., 5:101-107.

KEYWORD: personal, exposure, monitor, source,outdoor, NO2, model, field, source, home, appliance

Using integrating NO2 diffusion dosimeters, personal, indoor, and outdoor exposures were measured for nine families in Topeka, KS. The gas-cooking homes had indoor levels three times the outdoor levels. Members of the gas-cooking households had levels twice those of electric-cooking families and twice the outdoor levels. A linear model, which includes outdoor concentrations and stove types, explains 77% of the variance in observed NO2 exposure. The differential NO2 exposures in homes with and without gas stoves should be considered in epidemiologic studies of the health effects of air pollution.

0603
Dockery, Douglas W., and Spengler, John D. (1981) "Personal exposure to respirable particulates and sulfates", J. Air Pollut. Control Assoc., 31:153-159.

KEYWORD: particulate, model, outdoor, personal, exposure, field, SO4, activity

Personal exposure to respirable particulates and sulfates was measured by 37 volunteers in Watertown, MA, and Steubenville, OH. These measurements were compared with simultaneous measurements of outdoor ambient concentrations and measurements in the participant's homes. This limited sample showed that mean personal exposure for each city was related to the mean outdoor levels for the city. Within each city, however, individuals have markedly different exposure based on their activities. A time-weighted indoor/outdoor activity model gives improved estimates of exposure. However, the model only modestly improves estimates of personal exposures over those predicted from measured indoor concentrations alone.

0132
Dockery, D.W., and Spengler, J.D. (1977) "Personal exposure to respirable particulates and sulfates versus ambient concentrations", Harvard School of Public Health, 665 Huntington Ave., Boston, MA 02115 (11 pages).

KEYWORD: SO2, particulate, seasonal, outdoor, model, passive, smoking, personal, exposure, monitor, field, home

In support of a long-term prospective study of the health effects of SO_2 and particulates, a sampling program was undertaken to measure personal exposure to respirable particulates and sulfates in Watertown, MA. For 16 days in summer and 12 days in winter, 22 people carried portable samplers. Their exposures were compared to measurements taken by similar monitors in their homes and outdoor fixed-station monitors in the community. Ambient outdoor measurements underestimated personal exposure to respirable particulates and overestimated personal exposure to sulfates. Indoor measurements were more representative of personal exposure for both pollutants. Summer observations showed smaller differences among personal, indoor, and outdoor measurements than winter observations. Exposure to smokers, ambient outdoor levels, and home ventilation was most important in determining personal exposure to both particulates and sulfates. A simple linear model is proposed for personal exposure.

0704
Dockery, Douglas W., and Spengler, John D. (1981) "Indoor-outdoor relationships of respirable sulfates and particles", Atmos. Environ., 15:335-343.

KEYWORD: SO_4,model,personal,exposure,smoking,source, ventilation, monitoring, appliance, architecture, particulate, combustion

Indoor and outdoor concentrations of respirable particulates and sulfates were measured for at least 1 year in 68 homes in Topeka, KS; Watertown, MA; St. Louis, MO; Steubenville, ON; Kingston/Harriman, TN; and Portage, WI. A conservation of mass model was derived describing indoor concentrations in terms of outdoor concentrations, infiltration, and indoor sources. The measured data were analyzed to identify important building characteristics and to quantify their effects. The mean infiltration rate of outdoor fine particulates was approximately 70%. Cigarette smoking was the dominant indoor source of respirable particulates. Increased indoor concentrations of sulfates were associated with smoking and gas stoves. Full air conditioning of the building reduced infiltration of outdoor fine particulates by about 50%, while preventing dilution and purging of internally generated pollutants. The model for indoor respirable particulate and sulfate levels compared well with measurements.

0576
Dook, N., Lebret, E., Willers, H., Winkes, A., Boleij, J.S.M., and Brunekreef, B. (1986) "Estimating human exposure to nitrogen dioxide: results from a personal monitoring study among housewives", Environ. Int., 12(1-4):407-411.

KEYWORD: NO2, personal, exposure, field, outdoor, home, health, microenvironment, statistical, QA, foreign, Netherlands

Weekly average personal exposure to NO2 was measured in a population of housewives living in Wageningen, The Netherlands, together with weekly average indoor NO2 concentrations and indoor NO2 peak concentrations. In part of the population, the personal exposure measurements were repeated. The personal exposure and the indoor concentrations were in line with those in other studies in Holland. In general, they were higher than the levels found in the United States and Canada, but lower than those in Great Britain and Japan. The NO2 peak concentrations were high, especially in the kitchen. Relationships between personal exposure and indoor concentrations were investigated using bivariate and multiple regression techniques. Indoor concentrations were highly related to personal exposure. The contribution of peak concentrations to the explanation of personal exposure was small. An analysis of variance of the repeated personal exposure measurements showed that, due to variation of personal exposure in space and/or time, the "error" variance (within persons) was almost as large as the "true" variance (due to differences between persons). Therefore, personal exposure measurements should be reported to obtain reliable exposure estimates in health effects studies.

0503
Douglas, Richard L., Hans, Joseph M., and Wolff, Theodore A. (1978), "Working level screening survey of structures constructed of materials containing pumice", U.S. EPA, Office of Radiation Programs, Las Vegas, NV 89114 (20 pages). NTIS PB-282446.

KEYWORD: field, radon, architecture, exposure, home, statistical, source

Researchers describe the results of a screening survey conducted in several northern New Mexico communities to estimate the levels of radon progeny (working levels) in buildings constructed of materials containing pumice. Pumice, a locally produced material used as a lightweight aggregate in concrete blocks, contains slightly elevated levels of natural radionuclides. The results indicate that the use of pumice block may increase the working levels in the structure, but the effect is so small that it is difficult to separate it from background variations and from the variability caused by other parameters.

0700
Doyle, S.M., Nazaroff, W.W., and Nero, A.V. (1984) "Time averaged indoor radon concentrations and infiltration rates sampled in

four U.S. cities", Health Phys., 47:579-586.

KEYWORD: radon, seasonal, home, field, model, monitor, sampling, track-etching, radiation, ventilation

Indoor radon concentrations, measured in 58 houses in 4 U.S. cities during a 4- to 5-month period during the winter and spring of 1981-82, varied from 0.1-16.0 picoCuries/Liter (pci/L). Average infiltration rates were determined for each house during the same period by measuring the effective leakage area and using an infiltration model. The rates ranged from 0.2-2.2 air changes per hour. Indoor radon concentrations correlated poorly with infiltration rates for houses within each city as well as for the entire sample. Differences in radon entry rates among houses thus appear to be more important than differences in infiltration rates in determining indoor radon levels. This conclusion is consistent with previous indications from grab-sample measurements. Radon entry rates and indoor concentrations were generally higher in houses in Fargo, ND, and Colorado Springs, CO, than in houses in Portland, ME, and Charleston, SC.

0010
Duan, Naihua (May 1981) "Microenvironment types: a model for human exposure to air pollution", SIMS Technical Report No. 47, Stanford University, Dept. of Statistics, Stanford, CA 94305 (24 pages).

KEYWORD: activity, SHAPE, model, microenvironment, exposure, EPA$

A conceptual model is presented for computing actual human exposures to air pollution. The model sums the product of the pollutant concentration experienced in each of many microenvironments and the time each person spends there. A microenvironment is a location of relatively homogeneous pollutant concentration (home, office, subway, etc.) that a person occupies during normal daily activities. The concepts embodied in the Simulation of Human Air Pollution Exposure (SHAPE) computer model were based partly on this work.

0143
Duan, Naihua (Jan. 1985) "Application of the microenvironment monitoring approach to assess human exposure to carbon monoxide", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (88 pages), NTIS PB85-228995.

KEYWORD: CO, methodology, activity, pattern, microenvironment, personal, exposure, monitor, sample, design, EPA$

This study applies the microenvironment monitoring (MEM) approach to estimate exposure to CO, using activity time data from the Washington Urban Scale Study and CO concentration data from the CO Microenvironment Study (COMS). Estimated MEM exposures are then compared with estimated personal monitoring (PM) exposures. MEM exposures are about 40% higher than PM exposures, and MEM exposure is a powerful predictor of PM exposure. On log-scale, MEM exposure has the correct span relative to PM exposure; the discrepancy between the two sets of estimates is a constant drift. Two major factors could explain this discrepancy. First, COMS might have oversampled microenvironments with high CO concentrations. Second, PM exposures might underestimate actual exposure because of battery failure. Enhanced personal monitoring, another microenvironment approach, should be used in future exposure studies. When only the MEM approach is feasible, microenvironments should be sampled by a weighted sampling scheme or a simulated human activity scheme. This study also evaluates classification schemes for microenvironments.

0032
Duan, Naihua (1982) "Models for human exposure to air pollution", Environ. Int., 8:305-309.

KEYWORD: model, personal, exposure, monitor, sampling, activity, microenvironment, EPA$

Four models for human exposure to air pollution are compared. The simple microenvironment monitoring model measures pollutant concentrations at fixed locations, regarded as proxies for similar locations or microenvironments. Since this model does not require pollutant measurements on the individual level, it is easy to implement. The model can estimate the average exposure in a population but cannot estimate the variability and distribution of individual exposures. The replicated microenvironment monitoring model provides some estimates of the variability and distribution. However, because of the possible discrepancy between distributions of the microenvironment concentrations and individual concentrations, some adjustment might be necessary. Integrated personal monitoring allows direct estimates of the average exposure, as well as the variability and distribution of exposures in each microenvironment type. Moreover, such monitoring can also be conducted in conjunction with a two-stage sampling scheme, using information from a large data base on activity patterns, and thereby making more efficient use of the monitoring data. It is also easier to adjust for a possible Hawthorne effect in this design.

0616
Dudney, C.S., et al. (1986) "Indoor pollutants in 70 houses in the Tennessee Valley area: study design and measurement methods",

Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 116-127. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: NO2,CO2,CH2O,VOC,PAH,O3,CO,QA, particulate,home, source, architecture,radon,sampling, outdoor, ventilation, methodology

Levels of NO2, formaldehyde, vapor-phase polynuclear aromatic hydrocarbons, respirable particles, radon, and other parameters related to indoor air quality are being measured with passive monitors in a year-long study of indoor air quality in 70 houses in the Tennessee Valley area. Criteria for house selection included presence of a lower level with cement floor, one or more block walls in contact with the soil, and proximity to one of four cities in the region (Knoxville and Chattanooga, TN; and Birmingham and Florence, AL). Houses range in age from newly constructed to about 40 years old, typically have more than 2,000 square feet of finished floor space, and encompass a garage in the lower level. Six houses near Knoxville were selected for intensive study. During the summer of 1985, a nearly continuous record of NO2, CO, CO2, O3, particulate matter, air exchange rate, and air movement were made. Simultaneously, passive monitors identical to those used throughout the study were deployed in the houses for increased replication.

0229
Dudney, C.S. and Walsh, P.J., Eds. (1981) "Report of ad hoc task force on indoor air pollution", Oak Ridge National Laboratory, Oak Ridge, TN 37831 (190 pages). NTIS ORNL/TM-7679.

KEYWORD: radon, exposure, energy, NO2, particulate, CO, CH2O, asbestos, literature

The quality of air within a structure is likely to be affected by energy-conserving modifications made on that structure. Information was reviewed on indoor air pollution and the potential impact on human health of energy-efficient residences. Studies that have been done and those in progress indicate that indoor air pollution may significantly affect human health. The task force concluded from its investigations that: (1) the indoor environment is likely to include exposure to radon daughter nuclides, formaldehyde, CO, NO2, respirable particulates, and asbestos, as well as other undefined pollutants, (2) indoor exposure may constitute 80% to 95% of the total exposure for some pollutants, and (3) studies have not been done to provide a basis for adequate assessment of indoor air quality.

0173
Eckmann, A.D., Dally, K.A., Hanrahan, L.P., and Anderson, H.A. (1982) "Comparison of the chromotropic acid and modified pararosaniline methods for the determination of formaldehyde in air", Environ. Int., 8:159-166.

KEYWORD: CH2O, methodology, sampling, home, field, QA, laboratory

Follow-up tests were performed in 25 complaint homes previously investigated by the Wisconsin Division of Health to determine ambient formaldehyde concentrations. Four collection methods were compared in each home: (1) midget impingers containing double distilled water and immersed in ice baths, (2) midget impingers containing 1% sodium bisulfite solution and immersed in ice baths, (3) midget impingers containing 1% sodium bilsulfite solution but with no ice bath, and (4) a refrigerated, complete sampling unit developed at Lawrence Berkeley Laboratory that used double distilled water as the collection medium. Four types of sampling trains were operated simultaneously in a bedroom, collecting specimens within an area of about 4 square feet. In the kitchen or living room, all sampling trains, except the impingers containing 1% sodium bisulfite solution and immersed in ice baths, were operated together. Samples collected by these three trains (midget impingers and personal sampling pumps) gave similar results. All specimens collected in water were analyzed using both the chromotropic acid and pararosaniline analytical methods. Quality-control specimens prepared in the laboratory showed excellent agreement between the two methods; however, field specimens through which air had been drawn were assigned lower values using the pararosaniline method. Special precautions were taken to determine and limit sources of error.

0563
Edling, C., Wingren, G., and Axelson, O. (1986) "Quantification of the lung cancer risk from radon daughter exposure in dwellings--an epidemiological approach", Environ. Int., 12(1-4):55-60.

KEYWORD: radon, lung, source, exposure, field, health, smoking, statistical, home, foreign, Sweden

Some epidemiological studies have suggested a relationship between the concentration of decay products from radon (i.e., radon daughter exposure) in dwellings and lung cancer. Further radon measurements have indicated that both building material and particularly the radioactivity in the ground is of importance for the leakage of radon into the houses. A survey is underway in 15

Swedish municipalities with alum shale deposits; in one area, building materials, ground conditions, and occupant smoking habits are being considered. The study is small, but the results suggest that there is a risk and that there is a multiplicative effect from smoking and radon daughter exposure. About 30% of the lung cancers in the studied population might be attributable to elevated and potentially avoidable exposure to radon and its daughters.

0583
Ellett, William H., and Nelson, Neal S. (1985) "Epidemiology and risk assessment: testing models for radon-induced lung cancer", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds.,"Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 79-107.

KEYWORD: radon, lung, exposure,dose, model, risk, literature, QA, epidemiology, health

A number of risk assessments have been developed to measure the potential risk from indoor radon. Although all use essentially the same epidemiologic data base, estimated cancer risks differ by a factor of 6 or more, depending on the assumptions made in the subsequent analysis. The end result is that the estimated risks are relatively independent of the observed data. The researchers set out to answer two questions primarily: (1) how closely does a particular assumption actually model the clinical observation and (2) what is the numerical effect of a given assumption on the final risk estimate? The investigators compared the assumption made by various groups of risk assessors (International Commission on Radiation Protection, National Council for Radiation Protection, U.S. EPA, etc.) and attempted to identify the crucial assumptions that lead to such a wide numerical range in the estimated risks of lung cancer attributable to indoor radon.

0732
Englert, N., von Nieding, G., and Seifert, B. (1986) "Field study concerning infant respiratory diseases in relation to short-term increased air pollution (smog episodes) with reference to extensive indoor/outdoor measurements", proceedings of the 7th World Clean Air Congress, Sydney, Australia, sponsored by the International Union of Air Pollution Prevention Associations, pp.274-277.

KEYWORD: biomonitoring,lung, NO2, SO2, combustion,smoking,source, outdoor, health, foreign, West Germany

Pseudocroup (Croup Syndrome, acute stenosig laryngotracheitis) was studied in West Berlin in winter 1984/85 in cooperation with the five local pediatric hospitals. This study consisted of a retrospective study with 2,300 children, a prospective study with 500, and an observational study with 41. The results of the first two parts suggest that air pollution influences incidence of pseudocroup when analysed by time and location. The third study is being evaluated.

0397
Ericson, Sven-Olov, and Schmied, Hannes (1985) "The first long term comparison of techniques for passive integrated measurement of radon and radon daughter concentration performed in an occupied dwelling", Sci. Total Environ., 45:405-415.

KEYWORD: radon, home, exposure, methodology, QA, foreign, Sweden

The accuracy and variance of passive integrating detectors for radon and radon daughters presently in use in Sweden have been studied. The results have encouraged the development of improved calibration procedures for some tested detectors. All tested detectors that are in general use in Sweden are reasonably accurate.

0500
Esmen, Nurtan A. (1978) "Characterization of contaminant concentrations in enclosed spaces", Environ. Sci. Technol., 12(3):337-342.

KEYWORD: ventilation, statistical, exposure, methodology, model, source

Generalized equations for contaminant concentration buildup and decay are developed for an enclosed, ventilated space. The generalized equations take local mixing factors and source characteristics into account, and the illustrative cases show that the usual method of estimation can be totally erroneous.

0197
Everett, J.J., and Dreher, T.J. (1982) "Institutional aspects of indoor air pollution in energy efficient residences", Environ. Int., 8:525-531.

KEYWORD: regulation, legal,liability,health, architecture, energy

This paper examines the institutional constraints regarding indoor air pollution that exist or may be imposed on the housing industry. These constraints may be manifested in building codes and health laws, tax incentives and spending subsidies, and/or regulations restricting the activities of the industry itself. It also assesses the potential liabilities of designers, manufacturers, builders, and owners of energy-efficient residences should they fail to take appropriate actions to address indoor air quality problems. These liabilities may result from product liability (defective design or manufacture), breach of warranty, or negligence, causing harm to people from indoor air pollution. Currently, institutional controls relating to residential air pollution are inadequate, and many of the technical questions regarding the problem have not been resolved.

0686
Feigley, Charles E., and Chastain, James B. (1982) "An experimental comparison of three diffusion samplers exposed to concentration profiles of organic vapors", Am. Ind. Hyg. Assoc. J., 43:227-234.

KEYWORD: hexane, tetrachloroethane, VOC, sampling, methodology, QA, benzene, ketone, ethylbenzene, methylethylketone

Three commercial diffusion samplers were evaluated at different concentration-time profiles of organic vapors in air to investigate possible sample loss. Separate sets of experiments were carried out for ethylbenzene, methylethyl ketone, n-hexane, and 1,1,2,2-tetrachloroethane. Time-weighted average concentrations estimated from diffusion samplers were compared with those from continuous infrared absorption measurements. The overall mean bias was +7.0%, although considerable difference from the mean bias was observed for individual combinations of samplers, exposure profiles, and compound. The overall coefficient of variation was 6.4%. No significant sample loss was observed, but the bias was more negative for constant concentrations near the Federal standard and the shorter exposures at higher concentrations.

0459
Ferris, Benjamin G., Jr., et al. (1979) "Effects of sulfur oxides and respirable particles on human health: methodology and demography of populations in study", Am. Rev. Resp. Dis., 120:767-779.

KEYWORD: SO2, particulate, outdoor, personal, exposure, monitor, health, statistical, demographic, distribution

As part of a study of health effects of SO2 and particulate matter, a cohort of adults 25 to 74 years of age living in 6 communities is being followed prospectively. This study had two components: (1) measurement of the air pollutant concentrations, especially SO2, sulfates, and respirable particulate matter; and (2) determination of the effects of these pollutant concentrations on human health. This paper presents the overall design of the study and the nature of the populations selected for evaluation. The researchers considered previous exposure to atmospheric pollutants and describe the data obtained from the assessment of health and exposures.

0586
First, Melvin W. (1985) "Constituents of sidestream and mainstream tobacco smoke and markers to quantify exposure to them", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 195-203.

KEYWORD: nicotine, benzo-a-pyrene, pyrene, exposure, phenol, NH3, NOx, CO, smoking, literature, methodology, biomonitoring,research

Identifying and measuring environmental tobacco smoke is quite difficult--hampered primarily by (1) determing which of the more than 3,000 chemicals in tobacco smoke to measure and (2) judging how well the selected compounds represent all airborne tobacco smoke that may be present in a diversity of indoor environments. Often, tobacco smoke components of greatest health interest are already present in air in very low concentrations, thus making collection and analysis especially difficult. This had led to the widespread use of easily measured smoke components such as CO and total suspended particulate matter as convenient surrogates for the constituents of real interest. The special problem associated with the use of these and most other surrogate compounds is the presence of other sources of the same or similar compounds unconnected with tobacco smoking and often generating higher concentrations. Nicotine is a unique compound associated with tobacco that appears in the particulate phase of smoke in relatively high concentrations. It has low volatility when present in smoke particles, has low reactivity in air, and can be detected and measured at extremely low concentrations in air by simple and reliable methods. Nicotine appears to be the ideal tracer for environmental tobacco smoke and a well-established metabolite of smokers; however, little information has been developed on the relationship of nicotine and other constituents in tobacco smoke after dilution and variable residence times in air.

0554
Fischer, P., Remijn, B., Brunekreef, B., and Biersteker, K. (1986) "Associations between indoor exposure to NO2 and tobacco smoke and pulmonary function in adult smoking and non-smoking women", Environ. Int., 12(1-4):11-15.

KEYWORD: exposure,NO2,smoking,lung,distribution,statistical,home, rural,demographic,epidemiology,health,foreign,Netherlands

Exposure to NO2 and tobacco smoke in the home was assessed in a population of adult women living in a rural area of the Netherlands. The population was a subpopulation participating in a large longitudinal study on the natural history and causes of chronic nonspecific lung disease. Statistically significant negative associations between pulmonary function and exposure to NO2 in the home were found in nonsmoking but not in smoking women. A negative but generally insignificant association was found between pulmonary function and exposure to tobacco smoke and pulmonary function in nonsmoking women.

0380
Fischer, Paul, et al. (1984) "Indoor NO2 exposure induced effects on pulmonary functions", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 219-225. NTIS PB85-104206.

KEYWORD: NO2, smoking, home, demographic, exposure, epidemiology, health, lung

The authors established exposure to tobacco smoke and NO2 in the home in a population of adult, rural, nonsmoking women. The population was a subpopulation participating in a large longitudinal study on the natural history and causes of chronic nonspecific lung disease. Statistically significant associations between pulmonary function and exposure to NO2 as well as tobacco smoke in the home were found in cross-sectional analyses. Longitudinal analyses yielded inconsistent results, probably due to the small number of subjects involved.

0424
Fitz-Simons, Terence, and Sauls, Harold B. (1984) "Using the HP-41CV calculator as a data acquisition system for personal carbon monoxide exposure monitors", J. Air Pollut. Control Assoc., 34(9):954-956.

KEYWORD: CO2, personal, exposure, monitor, EPA$, CO, methodology, QA, microenvironment

This paper describes experiences using the Hewlett-Packard HP-41CV system as a data management system interfaced with personal carbon monoxide monitors (General Electric Carbon Monoxide Detector, Model 15EC53CO3). In general, the HP-41CV proved to be reliable, adaptable, and easy to use. Problems with the monitor power source (battery failure) were more frequent than with the HP-41CV itself. Using the HP-41CV for the specific data-collection requirements of the Washington Microenvironment Study is a focal point of this presentation.

0683
Flachsbart, Peter G. (1985) "Prototypal models of commuter exposure to CO from motor vehicle exhaust", Paper no. 85-39.6, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: CO, data, emission, exposure, field, microenvironment, model, monitor, personal, regulation, vehicle, outdoor, source

This paper is directed to environmental engineers and policy analysts concerned with human exposure to motor vehicle exhaust. Regulators need to know how variation in vehicle emission factors contributes to variation in measured human exposure to those emissions. This paper presents prototypal models of commuter exposure to CO from motor vehicle exhaust. The models relate commuter exposure to CO as a dependent variable to several independent variables, including ambient air quality, meteorology, and traffic characteristics. Each model attempts to predict the average CO concentration in parts per million that the author was exposed to as he rode in his personal automobile on a 2.4 km (1.5 mile) link of a Honolulu arterial during the morning peak travel period. Exposure was measured using a General Electric personal CO detector connected to an integrator. Quality assurance procedures were followed to improve the accuracy of the exposure data. The EPA's MOBILE2 model was used to estimate the source strength of CO emissions from motor vehicles on the highway. Each model assumed that commuter exposure was a function of ambient CO levels plus a microenvironment contribution from motor vehicles on the highway. All models were evaluated for their explanatory power and statistical significance.

0024
Flachsbart, Peter G. (Dec. 1982) "Field survey procedures for monitoring carbon monoxide exposures of office workers and merchants in the Washington metropolitan area", Report under cooperative agreement no. CR-810344-01-0, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (17 pages). Not available from NTIS.

KEYWORD: CO, methodology, office,microenvironment,EPA$, exposure, monitoring

A protocol is described for surveying the CO exposures of office workers and merchants in the Washington, DC, metropolitan area for 6 weeks beginning in January 1983. This protocol specifies which building microenvironments are to be surveyed, how frequently and how long they are to be surveyed, what monitoring instrumentation is to be used, and what types of data are to be collected.

0011
Flachsbart, Peter G. (Sept. 1982) "Field survey procedures for measuring carbon monoxide exposures to commuters in the Washington metropolitan area", Report under cooperative agreement no. CR-810344-01-1, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (41 pages). Not available from NTIS.

KEYWORD: CO, source, QA, vehicle, interior, field, methodology, microenvironment, EPA$, exposure

A protocol has been developed to monitor CO exposures of commuters in the Washington, DC, metropolitan area. It specifies routes to be surveyed for measuring automobile, bus, rail, and pedestrian microenvironments. It also describes frequency and times of the surveys; data to be collected for air pollution, meteorological, route configuration, and traffic variables; and instrumentation, test vehicles, and technician qualifications. Data quality assurance planning is essential.

0430
Flachsbart, Peter G. and Ah Yo, Clayton J., (1986) "Test of a theoretical commuter exposure model to vehicle exhaust in traffic", Paper no. 86-79.4 presented at the 79th annual meeting on the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: model, vehicle, microenvironment, exposure, CO,personal, monitoring, EPA$

Existing models assume that a commuter's exposure inside a vehicle is about equal to the roadway concentration. In 1982, EPA funded a study to develop new microenvironmental models of commuter exposure to motor vehicle exhaust, using CO as an indicator pollutant and personal monitors equipped with advanced data loggers to measure and store commuter exposure data. The study focused on eight hypothetical automobile commuter routes during peak travel periods in the metropolitan Washington, DC, area during 6 weeks of winter 1983. Commuter routes, which ranged from 15 to 44 km in length, were divided into links of roughly 0.8 to 4.8 km. Two routes included downtown parking garages as termini for the morning trip and as origins for the evening, homeward-bound, trip. Starting times for each trip on any given date were chosen randomly to simulate different starting times among commuters. This paper presents a theoretical discussion of a microenvironmental model of commuter exposure, followed by an application and an evaluation of that model using data collected from the Washington study. The model shows that the prediction of commuter exposure to CO can be improved by exponentially diffusing roadway CO into the vehicle and decaying the initial CO that exists when the vehicle enters a link.

0671
Flachsbart, Peter G., and Brown, Dennis E. (1986) "A seasonal study of personal exposure to CO in indoor and outdoor microenvironments of Honolulu" Paper no. 86-6.9, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: field, CO, monitoring, EPA$, monitor, interior, outdoor, microenvironment, methodology, vehicle, seasonal

This paper describes a field study to determine whether or not Honolulu's fixed monitors accurately measure general public exposure to carbon monoxide (CO) in selected microenvironments of the city. Honolulu's fixed monitoring stations generally indicate that ambient CO concentrations have not exceeded the National Ambient Air Quality Standards (NAAQS) for CO. Using a General Electric personal monitor, instantaneous CO readings were taken at 1-minute intervals over an 8-hour period in Honolulu. The survey was first conducted on March 23, 1981, with replication once every 3 months for a year, for a total of 4 surveys. During each 8-hour survey, the authors visited the same microenvironments including parking garages, buildings on major streets, sidewalks adjacent to heavy traffic, and inside vehicles in traffic. Depending on the date, between 57.5% and 98% of the measured microenvironmental CO concentrations exceeded the hourly average of 1.1 ppm recorded at the nearest fixed station. At Honolulu's Ala Moana Shopping Center, the median CO concentration varied between 14 and 21 ppm, depending on the date, compared to medians of 1 to 5 ppm at other microenvironments. The exposure problem at the Ala Moana Center is due to the coexistence of business outlets, parking, and roadways under one roof.

0013
Flachsbart, Peter G., and Ott, Wayne R. (Feb. 1984) "Field surveys of carbon monoxide in commercial settings using personal exposure monitors", U.S. EPA, Office of Research and Development, Washington, DC 20460 (147 pages). NTIS PB84-211291.

KEYWORD: CO, microenvironment, personal,exposure, monitor, field, outdoor, EPA$, office

Methodology and findings are summarized from the first large-scale field survey of commercial settings using miniaturized personal exposure monitors for CO. A total of 588 commercial settings were visited, including retail stores, office buildings, hotels, restaurants, department stores, and adjacent sidewalk and street locations in five California cities and suburbs. Altogether, 5,000 CO observations were recorded at 1-minute intervals as the investigators walked along sidewalks and into buildings. Average CO concentrations in a 15-story office building with an attached parking garage were equal to or greater than 9 ppm (the National Ambient Air Quality Standard for an 8-hour exposure) on most of the first 10 floors on four of the seven visits, each visit on a different date. The temporal and spatial variabilities of CO concentrations and their relationships to fixed-station measurements are detailed.

0759
Flachsbart, P.G., Mack, G.A., Howes, J.E., and Rodes, C.E. (1987) "Carbon monoxide exposures to Washington commuters", J. Air Pollut. Control. Assoc., 37(2):135-142.

KEYWORD: model,vehicle, microenvironment, exposure, CO, personal, monitoring, assessment, statistical, EPA$, interior

Typical CO concentrations to which automobile, bus, and rail commuters of the Washington, DC metropolitan area are exposed were determined on 15 hypothetical routes during winter 1983. Each route was segmented into several discrete sections. In addition, the relative importance of several factors were assessed that explain variability in CO levels inside automobiles during rush-hour periods. Typical results were: automobile commuters were exposed to average CO concentrations ranging from 9-14 ppm over trips of 40 to 60 minutes; for bus commuters, 4-8 ppm for trips of 90 to 110 minutes; and rail commuters, 2-5 ppm for trips of 30 to 45 minutes. The most important factors influencing CO concentrations inside automobiles were section-to-section variability, day-to-day variability, and the interaction between section and commuting period. Variability in CO levels by route, driver, and factors specific to a particular commute were moderately important; and between- and within-monitor variation the least important. Increasing automobile speed from 10 to 60 miles per hour reduced average CO exposure by 35% regardless of commuting period. The study suggests that automobile commuters who begin their homeward trips from highly polluted downtown parking garages may carry residual garage concentrations with them as they travel along downtown streets.

0741
Flachsbart, P.G., and Brown, D.E. (1985) "Merchant exposure to CO from motor vehicle exhaust at Honolulu's Ala Moana shopping center", Paper no. 85-85.3, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: CO, field, personal, exposure, monitor, architecture, microenvironment, vehicle, source, methodology, EPA$

Ala Moana Shopping Center in Honolulu, is an example of a multilevel mix-parking and commercial structure. Honolulu's Uniform Building Code does not require mechanically operated ventilation at this center because the parking area is treated as an open parking garage. In reality, part of the parking area is a semienclosed structure. CO levels at the center were monitored on 30 dates from November 1981 through March 1982. On each date, a sample of 25 businesses was visited during the morning, afternoon, and early evening. At each business, three instantaneous CO readings were taken using a General Electric personal monitor, and employees were counted. The results indicate that employee exposure to CO was not a problem based on air quality standards of the Occupational Safety and Health Administration, but may be a problem based on National and Hawaii Ambient Air Quality Standards.

0712
Flachsbart, Peter G. (1985) "The effectiveness of priority lanes in reducing commuter travel time and exposure to CO on a Honolulu arterial", Paper no. 85-41.3, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: CO, field,personal, exposure, monitor, microenvironment, vehicle, source, methodology, statistical, EPA$

This paper is directed to transportation engineers and planners concerned with the effectiveness of Transportation System Management (TSM) strategies for relieving traffic congestion on urban arterials. The use of priority lanes (contraflow and withflow) for express buses, carpools, and other high-occupancy vehicles (HOVs) is an example of TSM. This paper presents the results of an empirical study of the effectiveness of priority lanes on a Honolulu arterial in reducing commuter travel time and exposure to CO from motor vehicle exhaust. Exposure was measured using a General Electric personal CO detector connected to an integrator. Quality assurance procedures were followed to improve the accuracy of the exposure data. Data collectors used their own motor vehicles and public buses as test vehicles to represent travel in restricted and unrestricted lanes of the highway. Survey results generally showed that priority lanes were effective in reducing commuter travel time and CO exposure. The reduction in travel time was about 46% less for carpools, 53% less for HOVs, and 60% less for express buses. The reduction in CO exposure was about 18% less for carpools, 28% less for HOVs, and 61% less for express buses. All results were statistically significant.

0023
Flachsbart, Peter G. (Dec. 1982) "Revised field survey procedures for monitoring carbon monoxide exposures of commuters in the Washington metropolitan area", Report under cooperative agreement no. CR-810344-01-0, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (37 pages). Not available from NTIS.

KEYWORD: CO, field, vehicle, interior, source, methodology, EPA$

A protocol is described for conducting field surveys for monitoring CO exposure of commuters in the Washington, DC, metropolitan area for 2 months, beginning January 1983. [This report revises BLIS #011.]

0286
Flachsbart, Peter G., and Ott, Wayne R. (1986) "A rapid method for surveying CO concentrations in high-rise buildings", Environ. Int., 12(1-4):255-264.

KEYWORD: CO,personal,exposure,monitor, source,methodology, field, EPA$, office, control

A rapid method for employing personal exposure monitors (PEMs) to measure CO concentrations in high-rise buildings is described. The purpose is to determine whether a CO problem exists in a building and, if so, what corrective actions should be taken. The methodology was applied to a 15-story building in Palo Alto, CA, where elevated CO concentrations were discovered on the first 11 floors. The source appeared to be an underground parking garage. A follow-up survey 4 years later revealed that mitigative measures designed to reduce these concentrations had been successful. The survey methodology is inexpensive and can be applied to a number of buildings in a city.

0114
Flachsbart, Peter G., and Brown, Dennis E. (Dec. 1985) "Surveys of personal exposure to vehicle exhaust in Honolulu microenvironments", Final report under cooperative agreement no.

CR-808541-01-3, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (166 pages). Not available from NTIS.

KEYWORD: CO,microenvironment,outdoor,personal, exposure, monitor, source, EPA$, vehicle, interior

This report describes a use of personal exposure monitors to measure exposure to CO in parking garage and roadway microenvironments in Honolulu, HI. A parking garage was monitored from November 1981 through March 1982, and two roadway sites were monitored from November 1981 through May 1982. The main purpose of the study was to determine the seriousness of CO exposure in the two microenvironments. CO concentrations in the parking garage exceeded the 1-hour National Ambient Air Quality Standard of 35 ppm on 60% of the sampling days and the 8-hour national standard of 9 ppm on every sampling day. CO concentrations in the parking garage exceeded the 1-hour State standard of 9 ppm on all sampling days and the 8-hour State standard of 4.5 ppm on 92% of sampling days. CO concentrations on the roadways exceeded 35 ppm once but exceeded 4.5 ppm frequently for several travel modes during the morning and evening rush hours.

0528
Flanagan, James B., and Ryan, Joseph (1983) "Results of testing diffusion-type nitrogen dioxide personal monitors at low concentration", Paper presented at national symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 369-379. NTIS PB84-148345.

KEYWORD: NO2, personal, monitor, exposure, EPA$, QA, methodology, sampling

EPA's Clinical Environmental Laboratories were used to test a commercially available diffusion-type personal NO2 monitor (based on a design by E.E. Palmes), under conditions simulating subindustrial exposure levels and while being worn by human subjects. As many other commercially available personal monitors, the Palmes tube is optimized for the higher levels of industrial exposure. The monitors were tested with low ambient pollutant concentrations under a variety of conditions to establish their accuracy, precision, collection efficiency, and the effects of orientation and human wearers. Researchers found that dosages as low as 2.0 ppm-hr could be measured reliably with the commercially available Palmes tube kit, although higher levels of exposure were detected more precisely. The monitor can be modified to improve sensitivity in the lower limits of exposure.

0473
Fleischer, R.L., and Turner, L.G. (1984) "Indoor radon measurements in the New York Capital District", Health Phys., 46(5):999-1011.

KEYWORD: radon, monitoring, home, energy, source, architecture, exposure, seasonal, microenvironment

Radon-222 concentrations were measured in 21 "energy-efficient" homes and 14 conventional homes in the New York Capital District. Typical concentrations were averaged over 6 or 12 months, using solid-state track detectors. Full-year averages were determined for 23 of the homes, including winter-to-summer variations. In a number of cases, radon-222 emanations from various construction materials and soil samples were measured and correlations were sought with indoor radon-222. Two major patterns emerged. The living areas of the energy-efficient homes without heat-storage masses had median radon concentrations 1.6 times higher than those for conventional homes, and the energy-efficient homes with heat-storage masses had four to five times the radon-222 of conventional homes.

0743
Fleischer, R.L. (1984) "Theory of passive measurement of radon daughters and working levels by the nuclear track technique", Health Phys., 47(2):263-270.

KEYWORD: radon, radiation, track-etching, exposure, laboratory, model

A theoretical basis is described for long-term measurement of the activities of the alpha emitters in air by the track-etching technique. Inference of the other activities allows deriving working levels. A set of absorber foils allows using the differing response to alpha particles of different energies to identify the relative abundance of the emitters and the importance of diffusion to surfaces. The method is appropriate for measuring long-term exposures to radon atmospheres in homes or mines.

0747
Fleischer, R.L. (1986) "Moisture and 222Rn emanation", General Electric Company, Corporate Research and Development, Schenectady, NY 12345 (3 pages).

KEYWORD: radon, source, humidity, literature, laboratory, field, model, soil

The release of radon-222 from rocks, minerals, and soils has long been described in the geochemical literature. More recently the health physics community has published information showing effects of moisture on radon release. The publications, however, do not seriously address the mechanisms by which radon is released from tailings, shale, soil, etc., and enters the atmosphere. Because most health physicists do not see the relevant literature, this note briefly summarizes what is known of mechanisms and presents some new experimental results.

0746
Fleischer, R.L., Giard, W.R., Mogro-Campero, A., Turner, L.G., Alter, H.W., and Gingrich, J.E. (Dec. 1980) "Dosimetry of environmental radon: methods and theory for low-dose, integrated measurements", Health Phys., 39(6):957-962.

KEYWORD: radon, monitor, home, health, track-etching,methodology, exposure, dose

Radon-222 is important as a possible health hazard, an indicator of subsurface uranium, and a potential aid to predict earthquakes. Suitably housed track detectors measured radon-222 quantitatively free of other radon isotopes and daughter nuclides. The technique was calibrated and showed linear response over a wide range of radon concentrations, times of exposure, and doses. Exposures down to 10 picoCurie per liter per day can be measured.

0167
Fleischer, R.L., Mogro-Campero, A., and Turner, L.G. (1982) "Indoor radon levels: effects of energy-efficiency in homes", Environ. Int., 8:105-109.

KEYWORD: radon, seasonal, energy, home, track-etching, exposure, health, ventilation, methodology, architecture, soil

In northeastern New York State, homes that are more airtight have three times the radon-222 levels of the conventional homes; they have other specific problems that are introduced or exaggerated by modern construction. For example, the two highest levels of radon in the solar homes studied would give extrapolated doses over 30 years that are known to produce lung cancer in 1% of uranium miners. Summer readings in more than one-half of the cases are different from winter ones by a factor of two or more, so that year-round measurements are necessary. The track-etching technique is ideally suited for such measurements. Radon emanation measurements on soils demonstrate highly variable release rates.

0742
Fleischer, R.L., Turner, L.G., and George, A.C. (1984) "Passive measurement of working levels and effective diffusion constants of radon daughters by the nuclear track technique", Health Phys., 47(1):9-19.

KEYWORD: radon, track-etching, architecture, monitor, laboratory

Working level ratios (WLRs) and the effective diffusion constants of radon daughters were measured using a special housing designed to provide a uniform diffusional environment at the passive detectors. For two of seven exposures, the measured scale of the diffusion was too large to satisfy the uniformity requirement. For the other five, it was satisfied, and reasonable WLRs were obtained. Such a housing could be used for extended area working level measurements, but it is too bulky for personnel dosimetry. Personnel dosimetry is possible in mines using a passive area measurement of WLR combined with individual passive radon-222 measurements.

0752
Fleischer, Robert L. (1982) "Lung cancer and phosphates", Environ. Int., 8:381-385.

KEYWORD: radon, phosphate, outdoor, health, statistical, source, distribution, radiation, research, lung, demographic

U.S. counties with phosphate mining or processing facilities frequently also have significantly elevated rates of mortality from lung cancer. The author compared areas having high mortality rates from lung cancer with those containing phophate deposits, mines, or processing plants. Both white and nonwhite populations showed correlations which are improbable by pure chance. They should be examined on a site-by-site basis to establish whether radon-222 emissions from radium-222 in the phosphates are a significant factor in the elevated cancer mortality.

0749
Fleischer, Robert L. (1986) "Serendipitous dosimetry - an opportunity and an opportunity lost", General Electric Company, Corporate Research Development, Schenectady, NY 12345 (3 pages).

KEYWORD: dose, monitor, laboratory, literature, track-etching, health

Incidental dosimeters--glass, glazes on ceramics--existed at

Hiroshima and at Nagasaki, Japan sites of the World War II atomic bombings. Unfortunately, recognition of the possibility of using particle track-etching on such materials to measure radiation doses arose long after the atomic bombs were used. As a result, no adequate track dosimeters at Hiroshima or Nagasaki have been identified. The author cites plastic eyeglasses to be analogous dosimeters which might be used to measure radon exposure of people who die of lung cancer. Supporting arguments are presented for this idea.

0677
Fleischer, Robert L., Mogro-Campero, Antonio, and Turner, Larry G. (1983) "Indoor radon levels in the northeastern U.S.: effects of energy-efficiency in homes", Health Phys., 45:407-412.

KEYWORD: radon, track-etching, energy, monitor, health, seasonal, dose, home, architecture, exposure

The expectations of elevated radon-222 levels in modern energy-efficient homes prompted a survey of solar and conventional homes in northeastern New York State. The solar homes as a group have three times the radon-222 levels of the conventional homes, and specific problems exist that are introduced or exaggerated by modern construction. For example, the two highest levels of radon in the solar homes give radiation doses over 30 years that are known to produce lung cancer in 1% of uranium miners. Summer readings in more than half of the cases are different from winter ones by a factor of two or more, so that year-round measurements are necessary for precise dosimetry. The track-etching technique is ideally suited for such measurements.

0310
Fletcher, Robert A. (1984) "A review of personal/portable monitors and samplers for airborne particles", J. Air Pollut. Control Assoc., 34(10):1014-1016.

KEYWORD: particulate, personal, exposure, monitor,methodology,QA, literature, laboratory

Personal and portable particulate monitors and samplers for measuring and sampling airborne particulate matter are reviewed. These monitors and samplers are proving to be valuable tools for assessing individual exposure to environmental and occupationally generated particulates. The devices are characterized in terms of their sampling characteristics, monitoring or measurement techniques, particle size separation (50% cut point) capabilities, sampling flow rate, and sampling duration per one battery-charging cycle. All of the monitors and some of the samplers are commercially available. Commercial sources and originators (in the case of research devices) are listed.

0129
Fletcher, Robert A., and Bright, David S. (Jan. 1983) "NBS portable ambient particulate sampler", NBSIR 82-2561, National Bureau of Standards, Gaithersburg, MD 20234 (43 pages). NTIS PB83-165019/LL.

KEYWORD: particulate, methodology, sampling, personal,exposure, monitor, EPA$

The National Bureau of Standards portable ambient particulate sampler is designed to collect the respirable and inhalable particle size fractions at a sampling rate of 6 L/min for 24-hour sampling periods. Particulates are fractionated and collected by series filtration. The collection efficiency of the inlet is measured by comparison with isokinetic probes in the wind tunnel. The collection efficiency and sampling size characteristics of two small personal cyclone samplers are also reported.

0095
Fortmann, R.C., Borrazzo, J.E., and Davidson, C.I. (Aug. 1984) "Characterization of parameters influencing indoor pollutant concentrations", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp 259-264. NTIS PB85-104214.

KEYWORD: NO, NO2, CO, SO2, CH2O, appliance, combustion, home, source, energy

Emissions of NO, NO2, CO, SO2, and formaldehyde were measured by placing sampling hoods around gas-fired appliances at two residences in Pittsburgh, PA: a 1-year-old town house with tight weatherization and new appliances and a 50-year-old house without weatherization and with older appliances. Preliminary data suggest that emissions of NO, NO2, and formaldehyde are lower from the cast-iron burners of the older stove than from the pressed-steel burners of the new stove. CO emissions were similar. For range-top burners of both stoves, increases in the gas burn rate (kcal/min) resulted in greater emission factors (ug/kcal) for NO, but smaller emission factors for NO2. Emission factors for CO were lowest at intermediate gas burn rates. At the older house, fugitive furnace emissions were small, and water heater emissions were undetectable.

0133
Fowle, J.R. III, et al. (Aug. 1984) "Workshop proceedings: approaches for improving the assessment of human genetic risk--human biomonitoring", U.S. EPA, Office of Health and Environmental Assessment, Washington, DC 20460 (48 pages). NTIS PB84-154723.

KEYWORD: exposure, biomonitoring, regulation, risk, health, EPA$

Federal laws require a consideration of adverse health effects, including mutagenicity, in arriving at regulatory decisions on chemical substances. Certain laws require quantitatively balancing consequences of these risks with benefits provided by use of chemicals. Human genetic risk can be estimated indirectly based on data from animal experimentation and human somatic cells, but it is not practical to estimate genetic risk directly based on data from human germ cells. Indirect estimates are highly debated because of uncertainties about interspecies and interorgan extrapolations. Further complicating genetic risk assessments are uncertainties in extrapolating from effects observed in animals at high experimental doses to effects likely to occur in humans at much lower environmental levels. Comparative studies are needed to define the relationships between somatic cell and germ cell events and between experimental animals and humans. This work may involve studying at least one high-risk human population. These efforts will require long-term coordination of efforts among Federal and other government agencies, industry, and academia.

0723
Frank, Robert, and Lebowitz, Michael D. (1981) "Editorial: the risk of staying in", Am. Rev. Respir. Dis., pp. 521-522.

KEYWORD: smoking, multipollutant,microenvironment, risk,exposure, health, literature, research, energy, ventilation

This essay reviews the sources and health effects of the most common indoor air pollutants. Reduced ventilation to conserve energy has increased exposures and health risks. However, the health effects of many pollutants are uncertain, and reliable exposure data are not yet available. With further research, an efficient balance of energy conservation and air quality is achievable.

0328
Friberg, Lars, and Vahter, Marie (1983) "Assessment of exposure to lead and cadmium through biological monitoring: results of a UNEP/WHO global study", Environ. Res., 30:95-128.

KEYWORD: Pb, Cd, biomonitoring, demographic, smoking, health, QA, personal, exposure, foreign, multinational

This paper describes a UN Environment Programme/World Health Organization project on the assessment of human exposure to Pb and Cd. Several countries participated: Belgium, India, Israel, Japan, Mexico, People's Republic of China, Peru, Sweden, United States, and Yugoslavia. No laboratory started the monitoring before achieving satisfactory quality control. In each country, 200 teachers from one urban area constituted the target group for Pb and Cd in blood and cases of "sudden, unexpected death" for Cd in kidney cortex. Quality control samples were analyzed in parallel with the monitoring samples to ensure validity of the obtained results. Metal exposure varied considerably between areas. In general, males had higher blood Pb levels than females and smokers higher than nonsmokers. With a few exceptions, the values were lower than results reported in a recent study within the European communities. Cd levels were considerably higher among smokers than among nonsmokers.

0334
Fugas, Mirka (1984) "Estimation of total exposure to air pollution", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 1, recent advances in the health sciences and technology", Swedish Council for Building Research, Stockholm, pp. 53-57. NTIS PB85-104180.

KEYWORD: TEAM, biomonitoring, personal, exposure, monitor, model, literature

A short history of the development of total human exposure studies and the ways of accomplishing such assessments (biological monitoring, personal exposure measurements, modeling) are discussed. Past indoor air quality research focused on industrial environments. Fixed outdoor monitoring methods were found to be inadequate for measuring actual human exposure. The 1975 International Conference on Environmental Sensing and Assessment is cited as a turning point in attitude toward the need to improve human exposure assessment methods. With progress in microelectronics development came the possibility of producing devices capable of making direct, personal exposure measurements. The variety and use of personal exposure monitors summarized. Field study methodology and the components of exposure modeling are highlighted.

0573
Fugas, M. (1986) "Assessment of true human exposure to air pollution", Environ. Int., 12(1-4):363-367.

KEYWORD: personal, exposure, methodology, model, outdoor, health, biomonitoring, multipollutant, activity, literature, research

Only recently have scientists recognized the true exposure of people to a pollutant can only be assessed by considering all routes of intake (as well as concentration changes in the exposure medium). The exposure of the general population to air pollution was and often still is assessed from the data obtained at outdoor monitoring stations. The concept of total exposure was developed only after both the scientists studying health effects and those studying indoor climate came to the same conclusion: people's exposure does not stop once they come home. A historical review, recent developments, and current trends in the approach to total exposure assessment are presented.

0788
Fugas, M., et al (1972) "Concentration levels and urban particle size distribution of lead in the air of an urban and industrial area as a basis for the calculation of population exposure", Proceedings International Symposium on Environmental Health Aspects Of Lead, Amsterdam (Netherlands), October 2-6, 1972.

KEYWORD: exposure,occupational,Yugoslavia,foreign,outdoor,particulate, Pb,respirable

It was attempted to make a realistic evaluation of the total exposure to lead in air of certain population groups during their various outdoor and indoor activities. The size-weight distribution of lead in outdoor air and respirable lead fraction in occupational exposure were also determined.The results show that the exposure of an average citizen are not necessarily well represented by the average lead in air concentration of the area in which he lives. It is also shown that some populations are exposed to comparable weighted-average concentrations of lead in air, which could not be concluded from the data on occupational or urban exposure only.

0049
Fugas, Mirka (1975) "Assessment of total exposure to an air pollutant", Paper no. 38-5 in "International conference on environmental sensing and assessment, held September 14-19, Las Vegas, NV, vol. 2", Institute of Electrical and Electronic Engineers, New York, NY (3 pages).

KEYWORD: Pb, Mg, SO2, field, outdoor, personal,exposure, foreign, Europe

The relative merits of assessing the exposure of urban dwellers to an air pollutant from the data obtained by fixed outdoor monitoring networks, by personal sampling, and by calculation of weighted weekly exposure are discussed. Measurements of the concentration of Pb, Mg, and SO2 in air show some unusual indoor/outdoor relationships in the densely populated old centers of European-type towns. The estimated weighted weekly exposures calculated from these data show that the total exposure of an urban dweller to an air pollutant may deviate from a fraction to a multiple of the concentration recorded at the nearest outdoor monitoring station. This demonstrates the importance of adjusting the health-related monitoring program to actual human exposure patterns.

0737
Fugas, M. (1982) "Environmental monitoring of solvent exposure" Collins, A.J., Luxon, S.G., Eds., "Proceedings of the international symposium on the safe use of solvents held at the University of Sussex, Brighton, UK," pp. 306-315.

KEYWORD: solvent,methodology, literature, monitor, VOC, exposure, source, biomonitoring, environment,TEAM, foreign,Yugoslavia

This paper presents an overview of the history and development of methods to monitor human exposure to solvents. Total Human Exposure Assessment Methodology (TEAM) is outlined, with emphasis on the complex process of collecting air samples representative of the general population. Fixed ambient air monitoring and personal monitoring are compared. Both direct personal measurements and calculated time-weighted methods are outlined. Biological indices are discussed in a section on actual human solvent uptake (dose). Research on human exposure to solvents from both air and drinking water is reviewed. The author concludes that very little is known about human exposure to solvents and even less about contamination of the environment by solvents.

0744
Gammage, Richard B., et al. (1983) "Temporal fluctuations of formaldehyde levels inside residences", Frederick, Edward R., et al., Eds.,"Proceedings of the specialty conference on measurement and monitoring of noncriteria (toxic) contaminants in air, held in March of 1983 ", Publication SP-50, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, pp. 453-462.

KEYWORD: CH2O, home, field, seasonal,monitoring, energy,activity, ventilation, temperature, weather, control, architecture

Formaldehyde levels were measured in three houses (a 10-year-old home, a 3-year-old home prefitted with urea-formaldehyde foam insulation (UFFI), and a 2-year-old energy-efficient home) using active and passive air sampling devices with subsequent colorimetric analysis by the pararosaniline procedure. Diurnal formaldehyde concentrations inside each house varied by up to a factor of two. Over a year, concentration within the 3-year-old UFFI house varied by an order of magnitude. These changes appeared to correlate with factors such as temperature, weather, and occupant activity. Inside the 2-year-old house, the effects on formaldehyde levels of increased ventilation rate and the operation of a small charcoal-based air cleaner were studied. The results suggest that the levels were not inversely proportional to the air exchange rate, as one might expect, and that the air cleaner was ineffective.

0098
Gammage, R.B., White, D. Alan, and Gupta, K.C. (Aug. 1984) "Residential measurements of high volatility organics and their sources", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 157-162. NTIS PB85-104214.

KEYWORD: VOC, ventilation,field,home, gasoline,exposure, outdoor, source

An ongoing study is measuring the levels of volatile organic chemicals (VOCs) inside 40 homes in east Tennessee and identifying some of their sources. This report focuses on VOCs with boiling points below 110 degrees. Concentrations indoors were usually at least 10 times higher than those of outdoor air. The highly volatile compounds were generally dominated by gasoline fumes. Attached garages, automobiles, stored gasoline, and motor oil were responsible for the ubiquitousness of gasoline in indoor air. Air drawn into air conditioning duct work located in attached garages proved to be effective in funneling gasoline and other engine exhaust fumes into the living zones of the house. Other types of VOCs, including chlorinated VOCs and their sources, are currently being studied. [See Hawthorne, BLIS #134, for an abstract of the final report.]

0658
Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds. (1984) "Indoor air and human health, proceedings of the seventh Oak Ridge National Laboratory life sciences symposium, Knoxville, TN, October 29-31, 1984", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118 (430 pages).

KEYWORD: methodology, multipollutant, source, health, exposure, monitoring, risk, personal

Occupants of work places and homes increasingly complained of discomfort and sickness as a result of energy conservation efforts of the 1970s. The conference was a recognition of the importance of developing a better understanding of the indoor environment. Data were presented on indoor levels and health effects in humans and animals from five principal classes of pollutants: radon, microorganisms, passive cigarette smoke, combustion products, and organics. Factors such as measurements, source characterization, habitat studies, health effects, risk analysis, and future research needs were examined for each class.

0615
Gammage, R.B., White, D.A., Higgins, C.E., Buchanan, M.V., and Guerin, M.R. (1986) "Total volatile organic compounds (VOC) in the indoor air of east Tennessee homes", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 104-116. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: VOC, field,sampling, halocarbon,exposure,home, aromatic, hydrocarbon, laboratory

Total volatile organic compounds (VOCs) were measured in the winter in eight homes in east Tennessee. The mean concentration of total VOCs indoors was 1.03 mg/m3, with a range of 0.09 to 3.67 mg/m3. The corresponding values for outside air samples were 0.08 mg/m3 and 0.003 to 0.44 mg/m3. Hence the indoor-to-outdoor ratios were about 10:1. There were marked differences in both the total loadings and complexities of VOC among different homes and within a given home. About 10 liters of air were drawn through composite sorbent traps containing Tenax GC and two carbonaceous resins. The trapped VOCs were desorbed thermally and analyzed by gas chromatography/flame ionization detection (GC/FID). The counts from all peaks in the chromatograms were integrated and used to estimate total VOCs relative to the FID response to a standard composed of chlorinated and nonchlorinated aliphatic and aromatic hydrocarbons. The most volatile compounds measured were alkanes, chlorinated hydrocarbons of any size, and oxygenated hydrocarbons with 2 or more carbons. The types of compounds that should be included in definitions of total VOCs are discussed.

0598
Gammage, R.B., and Kaye, S.V. (1984) "Abstract book: indoor air and human health", 7th Oak Ridge National Laboratory Life Sciences Symposium, Knoxville, TN, October 29, 1984 (72 pages).

NTIS DE85-001081.

KEYWORD: literature, multipollutant,exposure, source,methodology, personal, health, source, monitoring, risk

This volume contains the abstracts of papers presented at the Oak Ridge National Laboratory's 7th Life Sciences Symposium on Indoor Air Pollutants and Their Human Health Implications. The full papers are in BLIS #658, and abstracts are included individually in BLIS.

0248
Gammage, Richard B., and Hawthorne, Alan R. (April 1984) "Current status of measurement techniques and levels of formaldehyde in residences", Oak Ridge National Laboratory, Oak Ridge, TN 37831(31 pages). NTIS DE84-011660.

KEYWORD: CH2O, sampling, seasonal, source, methodology, home, QA, architecture, weather

For measuring levels of formaldehyde in residences, the trend is toward the increased use of passive integrating monitors. This popularity is due to ease of use, cost-effectiveness, ability to provide time-weighted-average concentrations over periods of one or more days, and a sensitivity sufficient to make accurate measurements down to the 0.01-ppm range. The more traditional modified National Institute of Occupational Safety and Health method lacks the sensitivity to make accurate measurements at the 0.1 ppm or lower concentrations that are encountered frequently inside houses. More rigorous comparisons of various monitoring systems should be conducted, under both laboratory and field conditions. Marked dependence of formaldehyde concentrations on building age is observed for different classes of dwellings, including modern conventional houses. Levels of formaldehyde generally average about 0.03 ppm in older conventional homes. In mobile homes and a fraction of new and urea-formaldehyde foam insulated homes, mean levels of formaldehyde frequently exceed 0.1 ppm. More systematic data are needed on the frequency and magnitude of short-term peak exposures as well as long-term seasonal variations in levels of formaldehyde. Limited studies have revealed diurnal and seasonal within-house fluctuations of two- and tenfold, respectively. Occasional excursions to 0.1 ppm seem to occur in most houses.

0631
Garry, V.F., Oatman, L., Pleus, R., and Gray, D. (Feb. 1980) "Formaldehyde in the home, some environmental disease perspectives", Minn. Med., February:107-111.

KEYWORD: CH2O, temperature, humidity, home, health, distribution, seasonal, exposure, source, architecture, field, demographic

Sources of formaldehyde (CH2O) in homes include urea-formaldehyde foam insulation (UFFI), urea-formaldehyde bonded structural materials, shampoos, and combustion. CH2O emits more rapidly from material when temperature and humidity are high. In response to health complaints from 275 Minnesota residents, the Minnesota Department of Health measured CH2O concentrations in their homes. Data on medical histories, demographics, and indoor CH2O sources also were gathered. Homes with strong CH2O sources and/or poor ventilation had higher CH2O levels. These homes tended to have more health complaints.

0292
Gebifugi, Istavan, and Korte, Friedhelm (Aug. 1984) "Indoor contamination of household articles through pentachlorophenol and lindane", Berglund, B., Lindvall T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 317-322. NTIS PB85-104214.

KEYWORD: pesticide,lindane,home,field,particulate, biomonitoring, PCP, foreign, Germany, wood

Household articles were analyzed for pentachlorophenol (PCP) and lindane concentrations in selected homes in West Germany. These chemicals were active ingredients in wood-preserving paints used in the study homes, resulting in measurable air contaminants and blood concentration levels. Most textile and timber samples contained high levels of PCP and lindane.

0172
Geisling, K.L., Tashima, M.K., Girman, J.R., Miksch, R.R., and Rappaport, S.M. (1982) "A passive sampling device for determining formaldehyde in indoor air", Environ. Int., 8:153-158.

KEYWORD: CH2O, sampling, methodology, outdoor, home, laboratory

A passive sampling device based on the principle of diffusion has been developed for determining formaldehyde (CH2O) in ambient air. The sampler consists of a capped glass tube in which CH2O is entrapped by NaHSO3 (sodium bisulfite) on a glass-fiber filter. In the field, the device collects a sample by being uncapped for a specified time. After being recapped, it is analyzed in the laboratory. Laboratory validation studies were conducted by exposing the sampling devices for 1 week to dry CH2O gas concentrations ranging from 0.05 to 0.80 mL/m3. Reproducibility was excellent, with relative standard deviations averaging 5.4% for five constant concentrations. The lower detection limit was 3.6 mL/m3 over 1 hour. In an occupational environment, an 8-hour sample would be sufficient to detect compliance with the Federal permissible exposure limit of 3 mL/m3 in the workplace; in a residential environment, a 1-week sample would allow detection of 0.025 mL/m3 for indoor air quality audits.

0467
George, A.C., Knutson, E.O., and Franklin, H. (1983) "Radon and radon daughter measurements in solar buildings", Health Phys., 45(2):413-420.

KEYWORD: radon, exposure, architecture, ventilation, energy

Measurements of radon and radon daughters in 11 buildings in five states, using active or passive solar heating, showed no significant excess in concentrations over the levels measured in buildings with conventional heating systems. Radon levels in two buildings using rock storage in their active solar systems exceeded the U.S. Nuclear Regulatory Commission's limit of 3 picoCuries/Liter (pCi/L) for continuous exposure in uncontrolled areas. In the remainder of the buildings, radon concentrations were normal. It appears that the slightly elevated indoor radon concentrations were a result of local geological formations and tightening of the buildings, rather than as a result of the solar heating technology.

0725
George, A. C., Lowder, W., Fisenne, I., Knutson, E.O., and Hinchliffe, L. (1983) "EML indoor radon workshop, 1982", U.S. Department of Energy, New York, NY 10014 (114 pages).

KEYWORD: radon, foreign, methodology, control, research, source, exposure, monitor, ventilation, model, home, multinational

A workshop on indoor radon, held at the Environmental Measurements Laboratory, U.S. Department of Energy, on November 30 and December 1, 1982, covered recent developments in radon and radon daughter research and development. There were 48 participants from the United States, Austria, Canada, France, Sweden, and People's Republic of China. Thirty papers were presented dealing with standardization and quality assurance measurement methods, surveys, measurements strategy, physical mechanisms of radon and radon daughter transport, and development of guidance standards for indoor exposures. The workshop concluded with a planning session that identified the following needs: (1) national and international comparisons of techniques for measuring radon and radon daughter concentrations, working levels, and radon exhalation flux density; (2) development and refinement of practical measurement techniques for thoron and its daughter products; (3) quantitative definition of the sources of indoor radon and the mechanisms of transport into structures; (4) better knowledge of the physical properties of radon daughters; (5) more complete and accurate data on population exposure to radon, which can only be met by broadly based surveys; and (6) more international cooperation and information exhange among countries with major research programs. This report contains all the papers presented at the workshop and an overview analysis. The recommendations and conclusions resulting from the workshop are also included.

0466
George, A.C., and Eng, J. (1983) "Indoor radon measurements in New Jersey, New York, and Pennsylvania", Health Phys., 45(2):397-400.

KEYWORD: radon, exposure, monitoring, home, distribution, field

The distribution of radon-222 in 33 buildings near Canonsburg, PA, Lewiston, NY, and Middlesex, NJ, was investigated over 2 years. Time-integrated measurements of radon concentration (repeated several times for 1- or 2-week periods during the study) were obtained in the living and working areas of the buildings. Average air concentrations of radon, measured over the study period, varied from 0.32 to 4.5 picoCuries/Liter (pCi/L) among the buildings, but in only one building did the annual radon concentration exceed the U.S. Nuclear Regulatory Commission's limit of 3 pCi/L for continuous exposure in uncontrolled areas.

0325
Georghiou, Paris E., Snow, David, and Williams, David T. (1983) "Formaldehyde monitoring in urea-formaldehyde foam-insulated houses in St. John's, Newfoundland, Canada: correlative field evaluation of a real-time infrared spectrophotometric method", Environ. Int., 9:279-287.

KEYWORD: CH2O, field,outdoor, methodology, home, source, weather, foreign, exposure, Canada

Formaldehyde air levels in a group of houses containing urea-formaldehyde foam insulation (UFFI) in St. John's, Newfoundland, Canada, were measured on at least four occasions. The method developed by the National Institute for Occupational Safety and Health and a portable, commercially available single-beam infrared spectrophotometer were used. Little correlation was found between the two methods. Formaldehyde air levels were significantly higher in the UFFI-insulated houses than in the control group, which did not contain UFFI. Large daily variations in formaldehyde levels could be observed in some selected UFFI houses, attributable mostly to changes in exterior conditions. In particular, direct sunlight on UFFI-containing walls greatly increased formaldehyde levels.

0465
Gesell, Thomas F. (Aug. 1983) "Background atmospheric 222Rn concentrations outdoors and indoors: a review", Health Phys., 45(2):289-302.

KEYWORD: outdoor, radon, literature, source, seasonal, EPA$, exposure, weather

The sources of outdoor and indoor atmospheric radon are examined. The variation of outdoor atmospheric radon with time of day, time of year, altitude, and geographic location is quantitatively assessed. Outdoor atmospheric radon concentrations for normal areas of the contiguous United States range between 100 and 400 pico Curies per cubic meter (pCi/m3), with the mean probably about 250 pCi/m3. Values for Alaska and Hawaii are an order of magnitude lower. Indoor atmospheric radon concentrations vary with time of day, geographic location, and distance above ground level.

0104
Girman, J.R., Allen, J.R., and Lee, A.Y. (1986) "A passive sampler for water vapor", Environ. Int., 12(1-4):461-465.

KEYWORD: personal, exposure, methodology, QA, sampling, humidity

This preliminary study reports on improvements made to a passive sampler for water vapor and on tests to determine its suitability for studies of indoor air quality. The tests demonstrated that it has the precision, accuracy, linear response with exposure, sensitivity, and capacity necessary for large-scale studies to determine absolute humidities inexpensively.

0176
Girman, J.R., Apte, M.G., Traynor, G.W., Allen, J.R., and Hollowell, C.D. (1982) "Pollutant emission rates from indoor combustion appliances and sidestream cigarette smoke", Environ. Int., 8:213-221.

KEYWORD: CO, CO2, NO, NO2, CH2O, particulate, source, combustion, model, laboratory, smoking, ventilation, appliance, kerosene

Indoor pollutants resulting from operating one of several combustion appliances, or from sidestream tobacco smoke, were measured in a 27-m3 environmental chamber under varying ventilation rates. The combustion appliances investigated were gas-fired cooking stoves, unvented kerosene-fired space heaters, and unvented natural-gas-fired space heaters. Results showed elevated levels of CO_2, CO, NO, NO_2, formaldehyde, and suspended particles from one or more of the pollutant sources investigated. Of the sources examined in this study, NO_2 from combustion appliances and particles from sidestream cigarette smoke appear to be the most serious contaminants of indoor air, using existing standards and guidelines as the criteria. An emission rate model was used to quantify the strengths of the pollutant sources, which are reported in terms of the mass of pollutant emitted per energy unit of fuel consumed or per mass of tobacco burned.

0230
Girman, J.R., Geisling, K.L., and Hodgson, A.T. (June 1983) "Sources and concentrations of formaldehyde in indoor environments", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720. NTIS PB83-015945.

KEYWORD: CH_2O, home ,combustion, energy, exposure, source, field, laboratory, appliance, architecture

Formaldehyde (CH_2O), a common component of resins used in many building materials, can be released from these materials into the indoor environment. Unvented combustion appliances such as ranges and heaters also emit CH_2O. Emission rates from a variety of combustion appliances are discussed, and the CH_2O concentrations detected in 40 residential indoor environments are summarized. Houses designed to be energy efficient had higher CH_2O concentrations than inefficient but weatherized houses.

0249
Girman, J.R., Hodgson, A.T., Newton, A.W., and Winkes, A.W. (1986) "Volatile organic emissions from adhesives with indoor applications", Environ. Int., 12(1-4):317-321.

KEYWORD: CH_2O, VOC, toluene, styrene, alkane, source, model, laboratory, architecture

Studies have shown that volatile organic compounds (VOCs) emitted from building materials are a potentially important source of indoor air pollution. In this study, solvent- and water-based adhesives were applied to an inert substrate and dried for at least a week. VOCs were cryogenically trapped and identified by gas chromatography/mass spectrometry (GC/MS) or sorbent trapped, solvent extracted and quantified by GC/flame ionization detection. Among the compounds emitted by adhesives were toluene, styrene, and a variety of normal, branched, and cyclic alkanes. The measured emission rates varied by three orders of magnitude. A simple, well-mixed-tank model was used to assess the potential impacts of the adhesives studied and to demonstrate that adhesives can be significant sources of VOCs.

0767
Girman, J.R., Allen, J.R., Apte, M.G., Martin, V.M., and Traynor, G.W. (1983) "Pollutant emission rates from unvented gas-fired space heaters: a laboratory study", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (53 pages). NTIS LBL-14502.

KEYWORD: combustion, CO2, CO, CH2O, NO, NO2, source, ventilation, laboratory, particulate, model, appliance

This study determined emission rates and source strengths of a variety of pollutants emitted from eight unvented gas-fired space heaters operated with well adjusted air shutters at partial and full input in a 27-m3 chamber under a range of ventilation conditions. Emission rates were also determined for some heaters with poorly adjusted air shutters. CO, CO2, NO, NO2, formaldehyde, and respirable suspended particles, were monitored as well as O2 consumption rates. Emissions of NO2 and CO2 from all heaters were high enough to cause concern, both in single-room environments and, based upon calculation, in residential-sized buildings. Depending upon the particular heater and its air shutter adjustment, emissions of CO and, to a lesser extent, formaldehyde can cause concern. Emission rates from this study can be used along with information about building characteristics to calculate pollutant levels in a wide variety of indoor environments.

0062
Godin, Gaetan, Wright, Geoff, and Shepard, Roy J. (1972) "Urban exposure to carbon monoxide", Arch. Environ. Health, 25(5): 305-313.

KEYWORD: CO, field, sampling, source, smoking, weather, outdoor, statistical, methodology, combustion, office

Some 500 "grab" samples of air were collected during normal urban life and analyzed for CO. Concentrations were correlated with sunshine, rainfall, wind speed, and traffic density using nonparametric and multiple-regression techniques. Local traffic density (td) accounted for 63% of the variance; equations based on td describe the CO exposure (log [x + 1] ppm) encountered by pedestrians (0.59 +/- 0.133 td) and car drivers (0.92 +/- 0.086

td). Attenuation away from busy streets is rapid. In downtown offices, concentrations follow the general atmospheric pattern. Smoking can bring indoor concentrations above permitted 24-hour levels.

0748
Godish, Thad (1983) "Interpretation of one-time formaldehyde sampling results from measurements of environmental variables", Frederick, Edward R., et al., Eds., "Proceedings of the specialty conference on measurement and monitoring of noncriteria (toxic) contaminants in air, held in March of 1983 ", Publication SP-50, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, pp. 463-467.

KEYWORD: CH2O, model, home, outdoor, temperature, architecture, humidity, laboratory, statistical

The relationship between formaldehyde levels obtained from a one-time sampling protocol and environmental variables measured at the time of sampling were evaluated for two residence/source populations using sample linear regression analyses. Significant correlations were observed between formaldehyde levels and outdoor temperature, outdoor/indoor temperature difference (T), indoor relative humidity (RH), and indoor absolute humidity expressed as water vapor pressure (VP). Significant correlations were also observed between outdoor temperature and RH or VP. Derived ratios from these variables were also evaluated. Significant correlations were observed between formaldehyde levels and the ratios T/RH, T/VP, RH/T and VP/T. T/RH was very strongly correlated with formaldehyde levels in urea-formaldehyde foam-insulated (UFFI) and conventional residences with miscellaneous low-level sources of formaldehyde. T/RH was suggested as a good predictor of formaldehyde levels and a useful tool in interpreting one-time formaldehyde sampling results. Means of the two residence/source populations did not differ significantly. However, maximum formaldehyde levels predicted from regression analyses were expected to be twice as high (0.10 ppm) in UFFI residences as those in conventional residences with miscellaneous low-level sources. Thus, comparisons of formaldehyde levels in residences with different sources must take into account the effect of environmental variables.

0240
Godish, Thad (1984) "Low cost sampler for formaldehyde and other indoor air contaminants", J. Environ. Health, 46(5):229-232.

KEYWORD: CH2O, sampling, health, methodology, field, economic

Investigation of indoor air quality complaints and air testing by local health agencies are often limited by lack of sampling equipment. The construction of a low-cost sampler for formaldehyde and other indoor air contaminants is described.

0280
Godish, Thad (1985) "Air quality", Lewis Publishers, Inc., P.O. Drawer 519 Chelsea, MI 48118 (372 pages).

KEYWORD: multipollutant, outdoor, literature, health, source, exposure, regulation, vehicle

Indoor and outdoor air are covered in this classroom text for graduate and undergraduate students in environmental science, environmental health, and industrial hygiene. A comprehensive overview gives attention to (1) indoor air, (2) effects on human and animal health and vegetation, (3) regulation, (4) automotive emissions, and (5) noise as an air contaminant. This text may also be used as supplementary reading for courses that focus on engineering aspects of air pollution, and for practitioners seeking a broader knowledge of their field.

0313
Godish, Thad, and Rouch, Jerome (1985) "An assessment of the Berge equation applied to formaldehyde measurements under controlled conditions of temperature and humidity in a mobile home", J. Air Pollut. Control Assoc., 35(11):1186-1187.

KEYWORD: CH2O, risk, statistical, home, temperature, humidity

Efforts to assess the relative exposure risks of indoor formaldehyde levels have been limited by the considerable variation in the results. A number of factors contribute, particularly temperature and relative humidity, which are reported to greatly affect emissions of free formaldehyde from urea-formaldehyde resins. The most widely used expression of formaldehyde levels as a function of temperature and relative humidity is the Berge equation. Studies were conducted in a single mobile home for nine combinations of temperature (20, 25, and 30 degrees C) and relative humidity (30, 50, and 70%). Average formaldehyde levels were measured for each of eight environmental regimes and standardized to 25 degrees C and 50% relative humidity. Results showed that, at the 95% confidence interval, the error rate would be approximately (+/-) 12%. The analysis suggests that, for the temperature and humidity range considered, the Berge equation is a reliable indicator of formaldehyde levels measured at one set of environmental conditions and standardized to another. The authors believe that the Berge equation can be used with confidence for field, laboratory, and regulatory purposes if users understand and respect its limitations.

0472
Goldsmith, W.A., Poston, J.W., Perdue, P.T., and Gibson, M.O. (1983) "Radon-222 and progeny measurements in 'typical' east Tennessee residences", Health Phys., 45(1):81-88.

KEYWORD: EPA$, radon, home, monitoring, field, architecture, source, microenvironment, methodology

Modified Wrenn chambers for continuous monitoring of radon-222, featuring several improvements, including a computer-assisted electronics package, have been developed at the Oak Ridge National Laboratory. Radon-222 concentrations in seven houses were monitored continuously for periods ranging from 4 to 18 days. Radon-222 concentrations in the basements of three of the seven houses were in excess of 100 Becquerels per cubic meter (Bq/m3) almost continuously. One residence had instantaneous concentrations approaching 1,000 Bq/m3. Samples of soil and building materials from these residences indicated that radium-226 concentrations were in the normal range (40 Bq/kg). Radon progeny were measured in five of these houses on a "typical" day. Results obtained were as follows: for basements, a geometric mean of 0.016 working levels (WL) (geometric standard deviation of 2.9); for upper floors, a geometric mean of 0.014 WL (geometric standard deviation of 2.9).

0423
Goldstein, B.D., et al. (1979) "The relationship between respiratory illness in primary school children and the use of gas for cooking: II - Factors affecting nitrogen dioxide levels in the home", Int. J. Epidem., 8(4):339-345.

KEYWORD: health, NO2, monitoring, outdoor, home, smoking, field, activity, foreign, Britain, children, appliance, lung

The study attempted to find an association between indoor levels of NO2 and respiratory illness and lung function in school children. NO2 was measured for 1 week during the winter outside and inside the homes of children (aged 6 to 7 years) who were living and attending primary schools in a defined 4-square-km area in Middlesbrough, Cleveland, UK. Outdoor levels of NO2 measured at 75 points within the area ranged from 14 to 24 ppb weekly average. Measurements were also made in 428 kitchens with gas stoves (range 5 to 317 ppb, mean 112.2 ppb) and in 87 kitchens with electric stoves (range 6 to 188 ppb, mean 18.0 ppb). In a random subsample of homes, NO2 levels in 107 children's bedrooms in homes with gas stoves ranged from 4 to 169 ppb, mean 30.5 ppb. In 18 bedrooms in homes having electric stoves the range was 3 to 37 ppb, mean 13.9 ppb. NO2 levels in homes with gas stoves were positively related to pilot lights, gas heating, tobacco smoke, and the number of people in the home. In homes having gas stoves, when data from 29 homes with high kitchen NO2 levels were compared to 29 homes with low NO2 levels, the number of meals eaten and the frequency with which the stove was used for heating and drying clothes were significantly greater in the high NO2 homes.

0092
Goldstein, I.F., Hartel D., and Andrews, L.R. (June 1985) "Monitoring personal exposure to nitrogen dioxide", Paper presented at the 78th Annual Meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (13 pages).

KEYWORD: NO2, sampling, QA, field, outdoor, personal, exposure, monitor

Possible sources of error that might contribute to the accuracy of personal exposure to NO2 are discussed. Major errors result from relying on outdoor assessments and ignoring indoor NO2 concentrations, which recently have been shown to be significantly higher in homes that have indoor sources of NO2. Smaller but significant errors result from inappropriate placement of indoor stationary samplers or the manner in which personal samplers are worn. The nonuniform spatial distribution, both vertical and horizontal, of NO2 indoors requires the careful validation of all personal exposure data obtained from both personal monitors and stationary samplers.

0567
Goldstein, I.F., Hartel, D., Andrews, L.R., and Weinstein, A.L. (1986) "Indoor air pollution exposures of low-income inner-city residents", Environ. Int., 12(1-4):211-219.

KEYWORD: NO2, exposure, health, personal, seasonal, home, field, source, combustion, epidemiology, appliance, activity

This report is based on a pilot project for a large epidemiologic study in which exposures to air pollutants will be related to both incidence and prevalences of inner-city asthma. NO2 concentrations were measured in three rooms as well as outdoors in 44 inner-city apartments with gas cooking stoves. From fall 1982 to spring 1984, 52 separate month-long series of 48-hour, time-integrated NO2 samples (Palmes tubes) were gathered. The 48-hour average NO2 concentrations taken within homes frequently exceeded the U.S. EPA outdoor annual mean NO2 standard of 100 ug/m3, reaching 300 ug/m3 in some homes. Short-term peaks of NO2 in kitchens were as high as 2,000 ug/m3, at a distance of 2.3 m from the floor, and 1,700 ug/m3, at 1.7 m from the floor. Activity records filled out by the inner-city residents, many of whom were asthma patients, indicated that they spent an unusually large percentage of time in their homes. On the basis of these activity patterns and the regular occurrence of high NO2 levels in inner-city apartments, individuals in this population are likely to have elevated personal exposure to this combustion by-product.

0363
Goldstein, I., Hartel, D., and Andrews L. (1984) "Indoor exposure of asthmatics to nitrogen dioxide", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 269-274. NTIS PB85-104198.

KEYWORD: outdoor, energy, health, personal, exposure, monitor, activity, allergen, epidemiology, NO2, lung, appliance

Researchers report an on-going study of exposure to NO2 in a low-income population in New York City. These homes are likely to accumulate high levels of NO2 because the relatively small apartments are well insulated for energy conservation, and gas cooking stoves are frequently used. Family members who participated (including a child with asthma) wore 48-hour personal NO2 samplers; duplicate NO2 samplers were placed in the kitchen, living room, bedrooms, and outside the windows of each apartment. All sampling was for 24- to 48-hour periods for 30 consecutive days. Gas stove usage and daily activities of study subjects were recorded to obtain a relationship among indoor and outdoor exposures, activity patterns, and personal exposures. Researchers confirmed high levels of NO2 in the homes and also observed humid conditions conducive to growth of bioallergens. Individual exposures are discussed in relation to the design of epidemiologic study of acute health effects in persons with asthma.

0174
Good, B.W., Vilcins, G., Harvey, W.R., Clabo, D.A., Jr., and Lewis, A.L. (1982) "Effect of cigarette smoking on residential NO2 levels", Environ. Int., 8:167-175.

KEYWORD: NO2, combustion, home, smoking, source, field, seasonal, outdoor, sampling, exposure, appliance, ventilation

Two studies evaluated the levels and sources of NO2 in approximately 90 homes in the Richmond, VA, area, during the weeks of August 5, 1980, and February 9, 1981. Continuous samplers were run in the living room, bedroom, kitchen, and outdoors. Additional data were collected concerning appliance use, heating and cooling plants, ventilation, and cigarette smoking. The largest contributor to NO2 concentration was gas-fired kitchen appliances. The mean kitchen level for homes with gas appliances during the winter study was approximately 188 ug/m3. Excluding participants with gas kitchens, incremental increases due to cigarette smoking were detected. The 7-day, 3-room average levels of NO2 in the homes of nonsmokers and smokers without gas-fired appliances were 12 and 15 ug/m3, respectively, in the summer. The corresponding winter values were 19 and 22 ug/m3. Furthermore, levels of NO2 in the homes of smokers or nonsmokers were generally below both the adjacent outdoor level and the National Ambient Air Quality Standard for annual exposure.

0619
Gordon, Glen E. (1986) "Receptor modeling: a promising alternative to traditional source apportionment methods", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 304-313. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: particulate, research, outdoor, source, multipollutant, model, methodology, organic, literature, acid

The traditional combination of source-emissions inventories and dispersion models for predicting ambient pollutant concentrations is not very accurate in a number of applications. An alternate method, receptor modeling, is becoming increasingly valuable as a complement to the traditional approach. Receptor modeling involves detailed analyses of particles and gases collected from ambient air and from sources important in the area in question. Contributions from the sources are identified on the basis of detailed composition patterns and other characteristics (e.g., particle morphology). Receptor modeling based on elemental compositions has been primarily used to determine sources of particles in urban areas. However, many sources are not well characterized by elemental patterns, especially sources that release mainly carbonaceous material. To detect emissions from these sources, investigators need to measure concentrations of some of the thousands of organic compounds in the gas or particle phases. Development of this approach has been hindered because of uncertainty regarding the fractions of various compounds that survive destruction by atmospheric reactions between the source and receptor. If stable tracers, either organic or inorganic, for the sources can be identified, less stable species could be treated by a new model called "hybrid receptor modeling." The latter includes source emissions, transformation, and deposition treatments similar to those of traditional models, along with the use of tracer species of certain sources, as in receptor models. Tracer use can eliminate many absolute uncertainties (e.g., dilution) common to dispersion modeling. The hybrid approach is now being used in attempts to provide an understanding of the sources, transformation, and deposition of sulfur species related to acid-deposition problems.

0399
Green, B.M.R., et al. (1985) "Surveys of natural radiation exposure in UK dwellings with passive and active measurement techniques", Sci. Total Environ. 45:459-466.

KEYWORD: radon, radiation, exposure, source, foreign,methodology, architecture, home, Britain

A representative sample of more than 2,000 United Kingdom dwellings was monitored for a year using thermoluminescent and etchable plastic dosimeters to measure gamma-ray dose rates and radon concentrations. The survey was carried out by mail. Each homeowner completed a questionnaire on the type of dwelling and its characteristics. These data will be used to assess the factors affecting indoor exposure. The mean gamma-ray dose rates were 0.062 and 0.057 micro Gray/hour (uGy/h) in air, and the mean radon concentrations were 25 and 18 Becquerels (Bq)/m3 for living areas and bedrooms, respectively. Other results of the preliminary data analysis are given. More detailed surveys were conducted in areas where the local geology indicated that elevated exposures to natural radiation might occur. More than 800 dwellings were visited and measurements made of several parameters. The mean gamma-ray dose rates varied from 0.05 to 0.10 uGy/hour in air. The mean radon concentrations varied from 14 to 520 Bq/m3. Other findings related to equilibrium factors and regional differences are discussed.

0341
Green, G.H. (1984) "The effect of vacuum cleaners on house dust concentration", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 87-92. NTIS PB85-104222.

KEYWORD: particulate, exposure, source, Canada, home, control, ventilation, foreign, dust, smoking

The results of tests on the mass concentration of house dust caused by the cleaning action and airborne dust in the exhaust of vacuum cleaners in seven homes in western Canada are compared to other investigations. Researchers found that the ambient dust level was similar to that found by others and confirmed observations of much higher levels due to smoking and reduced levels by electrostatic filters in heating systems. Central vacuum cleaners with outside exhaust had slightly lower concentration than portable models used in the houses. This and other studies found that other household activities contribute more or equal dust to the house atmosphere. The study concluded it is important to minimize all house dust contributions for those suffering from house dust allergies.

0108
Grimsrud, D.T., et al. (Aug. 1984) "Indoor air quality field survey strategies", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 215-220. NTIS PB85-104214.

KEYWORD: literature, radon, methodology,sample,design,monitoring

Changes in research goals and the availability of new instruments allow conducting new types of indoor air quality studies. This paper compares the advantages and disadvantages of each type of study. While intensive monitoring is expensive and limited to small sample sizes, its detailed measurements can reveal valuable information about source behavior and pollutant interactions. Large-scale surveys, on the other hand, yield broad information about weighted-average pollutant concentrations and are better suited for studies of the effects of regional or construction differences on indoor air quality. In large-scale surveys, the effects of occupant activities are automatically included. An intensive study can suggest that a ventilated crawl space implies a lower radon concentration in the living space of a house, while a large survey can test the hypothesis statistically. Large surveys do not replace intensive, detailed studies.

0552
Grimsrud, D.T., Nazaroff, W.W., Revzan, K.L., and Nero, A.V. (1983) "Continuous measurements of radon entry in a single-family house", Paper no. 83-9.8, presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (20 pages).

KEYWORD: radon, ventilation, temperature, pressure, water, home, source, field, exposure, architecture

This progress report describes detailed measurements of radon concentration, ventilation rate, and other environmental parameters that affect radon entry in a single-family house during a 6-month period. Average radon concentrations in the house varied between 0.1 and 18.4 picoCuries/liter (pCi/L) during this period; the mean was 3.1 pCi/L. Ventilation rates ranged from 0.03 to 1.00 air changes/hour (mean = 0.25 ach). The data show that the radon source strength varied substantially during the measurements. The environmental parameters measured are used to obtain a better understanding of the processes that influence radon entry into the house. The major radon entry site in this structure appeared to be the basement sump. A portion of the time variation in the entry rate can be associated with changes in the water level in the sump that couples and decouples the sump with an exterior drain tile system.

0531
Gunning, C., and Scott, A.G. (1982) "Radon and thoron daughters in housing", Health Phys., 42:527-528.

KEYWORD: radon, thoron, control, exposure, sampling, home, field, source, radiation, ventilation, foreign, Canada, architecture

A remedial action program is in progress at the town of Ellicott Lake, Ontario, Canada to reduce average radon daughter concentrations in occupied houses to below 0.02 working levels (WL). The average WL in a house is estimated from a series of air filter samples analyzed by the Kusnetz technique on the assumption that all alpha activity is due to radon daughters. Previous work showed that significant thoron daughter concentrations were present in the Elliot Lake uranium mines, where the activity ratio of uranium-238 to thorium-232 in the ore was approximately 3:1. Because the activity ratio in the surface soil and building materials used in the town is about 1:1, thoron daughters might represent a large fraction of the airborne alpha activity measured in houses. Accordingly, a study was organized to resolve this question. Radon and thoron daughter concentrations expressed in Working Levels were estimated by a modified Kusnetz technique (2 alpha counts). The air filter samples were taken each morning in house basements as part of the routine survey. Although the thorium activity is at least equal to the uranium activity in the surface environment at Elliot Lake, the WL(Tn) in houses is insignificant compared with the WL(Rn), and the remedial action limit of 20 mWL(Rn). Exceptions to this may occur in commercial buildings where there are large areas of unpainted concrete and poor ventilation, and in those few cases where the transit time of soil gas into the building is so short that the thoron does not decay significantly in transit.

0189
Gupta, K.C., Ulsamer, A.G., and Preuss, P.W. (1982) "Formaldehyde in indoor air: sources and toxicity", Environ. Int., 8:349-358.

KEYWORD: CH2O, home, literature, combustion, health, source

Formaldehyde, a highly reactive gas with a pungent odor, is released from a variety of sources, including urea-formaldehyde foam insulation, particle board, and plywood, as well as various combustion processes. Under controlled conditions, formaldehyde causes eye and nasal irritation at air concentrations of 0.24 mg/m3 and above. Exposure, residential or occupational, has been associated with eye, nose, and throat irritation, coughing, wheezing, skin rashes, nausea, and other symptoms. Formaldehyde is a sensitizer and is thought to be genotoxic. Recent studies indicate that formaldehyde is also a carcinogen in rats and probably in mice. Formaldehyde is likely to pose a carcinogenic risk to humans.

0400
Hagberg, N. (1985) "Some tests on measuring methods for indoor radon using activated charcoal", Sci. Total Environ. 45:417-423.

KEYWORD: radon, methodology, sampling, laboratory, QA, personal, exposure, monitor

Two methods have been tested for measuring indoor radon concentrations using activated charcoal. The first method is the well-known technique with direct gamma-ray measurements on the exposed canister after the sampling period. The other method uses a thermoluminescence dosimeter placed in the charcoal canister, giving an integrated value of the radon concentration. Measurements and intercomparisons with other integrating radon instruments were performed in an occupied dwelling. The measurements performed show a standard deviation of less than 10% for all exposure periods. This accuracy was considered sufficient for most cases.

0452
Halbert, M.K., Mazumder, M.K., and Bond, R.L. (1981) "Respirable particulates in household aerosols", Environ. Res., 26:105-109.

KEYWORD: particulate, aerosol,home, laboratory,source, pesticide, methodology

Optical microscopy, cascade impaction, and single-particle aerodynamic relaxation-time (SPART) analysis were used to determine the size spectra of five common household aerosol products. Median diameters obtained in the microscopy study agreed with those obtained in the SPART analysis; values ranged from 0.74 to 1.22 um in both studies. Mass median diameters obtained in the SPART analysis and in the cascade impaction study showed less agreement. Values for both techniques ranged from 1.95 to 3.80 um with the exception of the oven cleaner, which yielded a mass median aerodynamic diameter of 23.5 um in the impaction study.

0250
Halpern, Marc (July 1978) "Indoor/outdoor air pollution exposure continuity relationships", J. Air Pollut. Control Assoc., 28(7):689-691.

KEYWORD: outdoor, Pb, particulate, methodology, exposure

The relationships between indoor and outdoor pollutant concentrations and exposure gradients were evaluated using Pb particulates as an index contaminant. Pb was collected using a serial filtration technique and analyzed by atomic absorption spectrophotometry. Significant differences were observed between indoor and outdoor Pb levels and between indoor and outdoor ratios of the respirable and nonrespirable Pb particulates. The widely accepted hypothesis of a homeostatic balance between indoor and outdoor pollutant levels was thus refuted. Parameters other than outdoor pollutant levels also determine indoor air quality.

0607
Hammond, S.K., Leaderer, B.P., Roche, A.C., and Schenker, M. (1986) "A method to measure exposure to passive smoking", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 16-24. Not yet available from NTIS.

KEYWORD: personal, exposure, sampling, laboratory, field, office, smoking, methodology, particulate, nicotine

Concerns about the health effects of passive smoking and the large segment of the population exposed to environmental tobacco smoke (ETS) have contributed to the need to develop a method to measure exposure to ETS. Because tobacco smoke is a complex mixture, it is difficult to measure. Nicotine was chosen as a marker in these studies because, unlike other markers often used, tobacco smoke is the only important source of nicotine. Nicotine was collected onto filters treated with sodium bisulfate; it was then desorbed and analyzed by gas chromatography with nitrogen selective detection. This method can detect 1 ug nicotine/m3 in samples collected over 1 hour. The method was tested in an environmental chamber in which people smoked selected brands of cigarettes. The ambient nicotine concentrations were found to be similar despite the fact that the cigarettes had varying nicotine yields in the mainstream smoke. The ratio of nicotine to particulate matter in ETS was also constant. Nicotine exposure was measured using personal samples collected from office workers in the ETS breathing zone; it was found to be up to 28 ug/m3 ETS an 8-hour workday.

0202
Handy, R.W., et al. (1985) "Standard operating procedures employed in support of an exposure assessment study, vol. 4", U.S. EPA, Office of Research and Development, Washington, DC 20460 (662 pages). Not available from NTIS.

KEYWORD: TEAM, VOC, methodology, biomonitoring, water, sampling, QA, laboratory

This document sets forth the standard operating procedures (SOPs) that were used to support the Total Exposure Assessment Methodology (TEAM) study. The SOPs cover chemical sampling and analyses for volatile organic chemicals in personal air, fixed-site air, human breath, and drinking water samples. The volume also discusses procedures for the preparation of data files on chemical levels for statistical analysis, chain-of-custody for sample management, instrument calibration, and log notebook maintenance.

0311
Hanrahan, L.P., Anderson, H.A., Dally, K.A., Eckmann, A.D., and Kana, M.S. (1985) "Formaldehyde concentrations in Wisconsin mobile homes", J. Air Pollut. Control Assoc., 35(11):1164-1167.

KEYWORD: CH2O, temperature, seasonal, field, statistical, source, home, exposure, architecture

Mobile homes rely on particle board and hardwood plywood panelling as structural components. As a result, these prefabricated construction materials may emit formaldehyde into the home, because urea-formaldehyde resins are used as the bonding agents in most pressed-wood stocks. Indoor formaldehyde exposure concentrations were measured in 137 mobile homes. The homes were selected based on the estimated age of the construction components and were studied serially for 9 months. Formaldehyde samples were obtained during monthly visits, using a modified chromotropic acid procedure developed by the National Institute for Occupational Safety and Health. Formaldehyde concentrations ranged from less than 0.10 ppm to 2.84 ppm, with a median of 0.39 ppm. Analysis of variance was performed on each home to determine the effects of visits and sampler location. Of the homes, 89% showed no sampler-placement effects, while only 10% failed to demonstrate between-visit variance effects. Regression models were constructed to predict household formaldehyde concentrations. Concentrations exhibited an inverse relationship with the age of the construction materials. A regression model based on home age and temperature predicted 82% of the formaldehyde variation.

0268
Hanrahan, L.P., Dally, K.A., Anderson, H.A., Kanarek, M.S., and Rankin, J. (1984) "Formaldehyde vapor in mobile homes: a cross sectional survey of concentrations and irritant effects", Am. J. Public Health, 74(9):1026-1027.

KEYWORD: CH2O, home, health, exposure, architecture, dose

In a study in Wisconsin, 65 owners of mobile homes volunteered for an assessment of indoor formaldehyde gas; 61 teenage and adult occupants completed health questionnaires. Formaldehyde concentrations ranged from <0.10 to 0.80 ppm, with the risk of eye discomfort showing a positive dose-response relationship.

0386
Hanssen, S.O., and Rodahl, E. (1984) "An office environment--problems and improvements", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 303-307. NTIS PB85-104206.

KEYWORD: health, ventilation, foreign, exposure, CH2O, CO2, SO2, styrene, toluene, temperature, humidity, Norway, office

Employees in a large office in Trondheim, Norway, complained about headache, tiredness, sickness, allergic reactions in eyes and noses, dry skin, respiratory diseases, etc., which they attributed to the ventilating system. However, preliminary investigations only partially verified this assumption. A more extensive investigation was then conducted with the intention of eliminating the cause of the problem.

0643
Harley, Naomi H., and Terilli, Terence B. (1984) "Factors controlling indoor radon levels", Institute of Environmental Medicine, New York University Medical Center, New York, NY 10016 (29 pages). NTIS DE84-012712.

KEYWORD: statistical, track-etching, radon, home, model, outdoor, ventilation, weather, exposure, QA, architecture, seasonal

This annual report to the U.S. Department of Energy summarizes the progress made during June 1983 to May 1984 in understanding the factors which contribute to indoor radon levels. Extensive measurements were made in a two-story single family dwelling with a basement and in a 25-story apartment building with a basement. Soil moisture, seasonal changes, diurnal cycles, ventilation, and climatic conditions were monitored. The data were compared to baseline data using a statistical software package. Isolated events were analyzed manually. Average conditions for both structures could be monitored. In addition, two types of track-etching film did not give comparable results. Reproducibility on paired duplicates exposed in a radon calibration room was also poor.

0506
Harley, Naomi H., and Altman, Stuart M. (1983) "Contract AC02 EV10374: Progress Report, June 1, 1982 to May 31, 1983", U.S. Department of Energy, Washington, DC 20585 (40 pages). NTIS DE83-013008.

KEYWORD: radon, field, home, outdoor, weather, pressure, model, exposure

A 1-year progress report describes the New York University Medical Center Institute of Environmental Medicine project on indoor radon variability and factors that may affect the variability. Data are collected in a high-rise apartment building and in a single-family dwelling. The effect of factors such as outdoor radon variability and meteorological parameters (temperature, humidity, precipitation, wind direction and speed, and barometric pressure) on indoor radon variability is examined. Modeling of indoor radon concentration has started. Apparently, indoor variability is highly dependent on outdoor variability.

0582
Harley, Naomi H. (1985) "Comparing radon daughter dosimetric and risk models", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 69-77.

KEYWORD: radon, exposure,dose, risk, model, health, epidemiology, demographic, literature, lung, miners

The basic data on lung cancer mortality resulting from inhaling short-lived radon daughters are obtained from four large studies of underground miners. The results of these studies, which will not be complete for perhaps another 20 years, must be used to project the lifetime risk to populations other than miners. The alpha dose delivered to the bronchial epithelium from inhaling the short-lived daughters can be used to assess the effects across populations, because it is the dose that confers the lung cancer risk. Three major dosimetric models have been developed by the National Council on Radiation Protection, the U.S. Environmental Protection Agency, and the International Commission on Radiation Protection. Three major risk projection models have been developed to evaluate current environmental and occupational exposures. These dosimetric models and risk projection models are critically reviewed with respect to their biological integrity, and the reasons for their widely divergent results are described.

0560
Harley, Naomi H., and Harley, John H. (1986) "Risk assessment for environmental exposures to radon daughters", Environ. Int., 12(1-4):39-43.

KEYWORD: radon, exposure, risk, health, dose, statistical, model, literature, lung, epidemiology, miners

Predicting the consequences of population exposures to radon daughters is based on experience with the high exposures and high exposure rates of underground miners. Because lung cancer, the expected consequence of exposure, develops late in life, the total mortality has not been completely expressed in the various mining groups. While there is general agreement on the lung dosimetry, predictions of lifetime risk by current models vary significantly. The need for a satisfactory model is great because average lifetime environmental exposures are about one-tenth those shown to have caused excess lung cancer in miners. This paper reviews the published approaches to this modeling.

0721
Harris, Curtis C. (1985) "Future directions in the use of DNA adducts as internal dosimeters for monitoring human exposure to environmental mutagens and carcinogens", Environ. Health Perspect., 62:185-191.

KEYWORD: methodology, exposure, research,epidemiology,laboratory, dose, health, cancer

Scientific opportunities generally arise when two or more research areas converge and/or methodology advances. This occurred at the turn of the 19th century in the field of infectious bacterial and fungal diseases. Research in the laboratory is now providing critical information on mechanisms of carcinogenesis, as well as new technological advancements, including those in immunology, biochemistry, and molecular biology. Epidemiological investigations have clearly demonstrated the importance of environmental exposure to carcinogens and have identified populations at high risk. It is now practical to integrate laboratory determinations into classic epidemiological approaches. Several markers -- for example, carcinogen - DNA adducts related to tumor initiation and perhaps to tumor conversion -- are currently being evaluated. Indicators of tumor promotion and progression also need to be developed. The potential of biochemical and molecular epidemiology to predict cancer risk in an individual before there is clinical evidence provides an exciting new opportunity in cancer research and prevention.

0680
Hart, Ronald W., Terturro, Angelo, and Neimeth, Lorraine, Eds. (1984) "Report on the consensus workshop on formaldehyde", Environ. Health Persp., 58:323-381.

KEYWORD: epidemiology, dose, CH2O, research, literature, health, exposure, risk

The Consensus Workshop on Formaldehyde representing academia, government, industry, and public interest groups addressed important toxicological questions concerning health effects. The participants, and the Executive Panel which coordinated the meeting, were chosen through a broadly based nomination process. The subcommittees considered the toxicological problems associated with formaldehyde in the areas of exposure, epidemiology, carcinogenicity-histology-genotoxicity, immunology-sensitization-irritation, structural activity-biochemistry-metabolism, reproduction-teratology, behavior-neurotoxicity-psychology, and risk estimation. Questions considered included the possible human carcinogenicity of formaldehyde, as well as other human health effects, and the interpretation of pathology induced by formaldehyde. These reports, plus introductory material on the procedures used in setting up the Consensus Workshop, are presented, along with a listing of the data base available to the panel chairman prior to the meeting and to the participants during the meeting. The data base was supplemented by information brought by the panelists. In addition, the workshop developed a consensus concerning a number of major points in formaldehyde toxicology and identified a number of major gaps in the understanding.

0073
Hartwell, T.D., Zelon, H.S., Leininger, C.C., Clayton, C.A., Crowder, J.H., and Pellizzari, E.D. (Aug. 1984) "Comparative

statistical analysis for volatile halocarbons in indoor and outdoor air", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 56-61. NTIS PB85-104214.

KEYWORD: VOC, halocarbon, statistical, outdoor, field, EPA$

Matched pairs of overnight indoor and outdoor ambient air samples were collected in three areas--Greensboro, NC (November 1980), Baton Rouge/Geismar, LA (January 1981), and Houston, TX (June 1981)--for the purpose of measuring human exposure to volatile halocarbons. The methods for collecting and chemically analyzing these data have been described previously (See Pellizzari, BLIS #107). The paper presents a detailed statistical analysis of the data. The following outdoor and indoor matched samples were available: Greensboro (20), Baton Rouge/Geismar (27), and Houston (11). The outdoor samples were collected from the backyards of respondents who gave indoor readings using personal monitors. Preliminary analysis presented here is for 12 volatile halocarbons that had a sufficient number of samples detected for meaningful statistical analysis.

0117
Hartwell, T.D., et al. (Jan. 1984) "Study of carbon monoxide exposure to residents of Washington, DC and Denver, Colorado, Part I", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (210 pages). NTIS PB84-183516.

KEYWORD: CO, methodology, distribution, biomonitoring, field, personal, exposure, monitor, activity, EPA$

A study was conducted in 1982-83 to evaluate a methodology for measuring the distribution of CO exposures with respect to daily activities in an urban area. CO concentrations were measured with personal exposure monitors (PEMs). The study involved telephone screening of households and selecting respondents in the metropolitan areas in and around Denver, CO, and Washington, DC. CO breath levels also were collected in Washington, DC. The target population in both cities consisted of the noninstitutionalized, nonsmoking adults between the ages of 18 and 70 years. Estimates of CO exposure for the winter of 1982-83 in Washington, DC, were obtained using the data base constructed from the raw CO levels and corresponding activities. The data consisted of hourly CO values, activity patterns with corresponding CO levels, and CO breath measurements corresponding to the PEM CO data. The population distribution of exposure is compared to the National Ambient Air Quality Standard for CO.

0076
Hartwell, T.D., Perritt, R.L., Zelon, H.S., Whitmore, R.W., Pellizzari, E.D., and Wallace, L. (Aug. 1984) "Comparison of indoor and outdoor levels for air volatiles in New Jersey", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 81-85. NTIS PB85-104214.

KEYWORD: VOC, field, outdoor, statistical, sampling, personal, exposure, monitor, home, EPA$

As part of the Total Exposure Assessment Methodology (TEAM) study, matched pairs of overnight indoor (personal monitor) and outdoor (fixed-site monitor) ambient air samples were collected from 85 study participants in Bayonne and Elizabeth, NJ, in 1981. These samples were analyzed for several volatile organic compounds. In general, for all the compounds examined, the percent detected and the concentrations were higher for the overnight indoor samples. Furthermore, the Spearman correlations between the indoor and outdoor levels were less than 0.50 for all compounds examined.

0727
Hartwell, T.D., Clayton, C.A., Michie, R.M. Jr., Whitmore, R.W., Zelon, H.S., and Whitehurst, D.A. (1984) "Study of carbon monoxide exposures of residents of Washington, D.C", Paper no. 84-121.4, presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (18 pages).

KEYWORD: CO, personal, home, outdoor, microenvironment, exposure, methodology,source,combustion,smoking,statistical,vehicle,field

A CO survey was conducted in Washington, DC, and Denver, CO, during the winter of 1982-83. The population exposure profiles were determined by use of statistical inference from a statistically drawn sample. The study provided sufficent data to determine exposure as a function of concentrations within significant microenvironments (home, in-transit, work, and leisure) and individual activity patterns. This paper describes the sampling in Washington and Denver, and the field work and analysis of Washington results.

0699
Harving, H., Korsgaard, J., Dahl, R., Pedersen, O., and Molhave, L. (1986) "Low concentrations of formaldehyde in bronchial asthma: a study of exposure under controlled conditions", Brit. Med. J. reprint (3 pages).

KEYWORD: CH2O, health, lung, laboratory, exposure

In this study of the effect of formalydehyde on the lower bronchial airways of hyper-responsive subjects, 15 nonsmoking volunteers (mean age 25) were exposed to 0.0, 0.12, and 0.85 mg/m3 formaldehyde, concentrations similar to those found indoors. The experiments were conducted in a double blind randomized fashion. In the group as a whole, lung functions did not change significantly after exposures. Histamine challenge tests performed immediately after exposure were highly reproducible and unaffected by exposure to formaldehyde. The study concludes that low concentrations of formaldehyde, while known to irritate the upper repiratory tract and mucous membrane, are of minor importance in development of pulmonary symptoms.

0025
Hasanen, E., Pohjola, V., Pyysalo, H., and Wickstrom, K. (1984) "Polycyclic aromatic hydrocarbons in Finnish sauna air", Sci. Total Environ., 37:223-231.

KEYWORD: PAH, benzo-a-pyrene, benzo-a-anthracene, smoke, wood, exposure, source, foreign, Finland

The concentrations of polycyclic aromatic hydrocarbons (PAHs) in the air of three types of wood-heated saunas in Finland were studied. The highest concentrations were found in the smoke sauna (total PAH 170 to 1550 ug/m3, benzo(a)pyrene 4.6 to 20 ug/m3), the second highest in the preheated sauna (total PAH 50 to 90 ug/m3, benzo(a)pyrene 3.4 to 4.5 ug/m3), and the lowest in the sauna heated by continuous burning of wood (total PAH 25 ug/m3, benzo(a)pyrene less than 0.1 ug/m3). The results clearly indicate that regular bathing in the smoke and preheated saunas increases the intake of PAH compounds (e.g., benzo(a)pyrene and benzo(a)anthracene).

0493
Hawthorne, A.R., Gammage, R.B., and Dudney, C.S. (1986) "An indoor air quality study of 40 East Tennessee homes", Environ. Int., 12(1-4):221-239.

KEYWORD: radon, track-etch, exposure, field, source, laboratory, microenvironment, architecture, home

This paper presents the results of radon monitoring in 40 east Tennessee homes that were a component of a larger study to evaluate indoor air quality. During two 3-month studies, passive integrating track-etch monitors were used in each home. In a subset of homes, a real-time monitor that provided hourly readings also was used. About 30% of the homes had radon levels greater than 4 picoCuries/liter. Homes with elevated radon levels were associated with local variations in geology, and most of the homes having higher levels were on the porous dolomite ridge partially surrounding Oak Ridge, TN.

0241
Hawthorne, A.R., Gammage, R.B., Dudney, C.S., Matthews, T.G., and Erdman, D.J., (1984) "Formaldehyde levels in forty East-Tennessee homes", Oak Ridge National Laboratory, Oak Ridge, TN 37831 (7 pages). NTIS DE84-016672/XAB.

KEYWORD: CH2O, home, outdoor, exposure, source, microenvironment, temperature, monitoring, field, architecture

Formaldehyde (CH2O) levels were measured extensively in 40 east Tennessee homes as part of a larger indoor air quality study. Measurements were made with passive, integrating monitors for a period of 24 hours in three rooms of each house and outdoors. Monthly measurements of this type were made in the study houses from April through mid-December of 1982. Over 6,000 CH2O field measurements were made. Older houses averaged 40 ppb formaldehyde, while houses less then 5 years old averaged 80 ppb. Formaldehyde levels exhibited a statistically significant temperature dependence in most homes with CH2O concentrations greater than 80 ppb, particularly in homes with urea-formaldehyde foam insulation.

0134
Hawthorne, A.R., et al. (Dec. 1984) "An indoor air quality study of 40 East Tennessee homes", Oak Ridge National Laboratory, Oak Ridge, TN 37831 (100 pages). NTIS DE85-007087/LL.

KEYWORD: NO2,NOx, CH2O,VOC, particulate, radon, home, CO, source, ventilation,combustion,design,monitoring,appliance,architecture

This report presents the study design and implementation, monitoring protocols, and a complete set of the data collected during the project. For 1 year, indoor air pollutants (CO, NO2, formaldehyde, volatile organics, particulates, and radon) were measured in 40 homes in east Tennessee. The houses were of various ages with different types of insulation and heating. During the study, older houses averaged 0.04 ppm formaldehyde, while houses less than 5 years old averaged 0.08 ppm ($P < 0.01$). The highest concentration of formaldehyde measured was 0.4 ppm in a new home. Diurnal and seasonal fluctuations in formaldehyde levels in some homes were as much as twofold and threefold, respectively. The concentration in indoor air of various organics was at least 10-fold higher than in outdoor air. CO and

NOx concentrations were usually <2 and <0.02 ppm, respectively, except when gas stoves or kerosene space heaters were operating, or when a car was running in the garage. In 30% of the houses, the annual indoor guideline for radon, 4 pico curies/liter, was exceeded. The mean radon level in ridgeline houses was more than twice that of valley houses. Operation of the central duct fan had the most impact on radon infiltration.

0627
Hawthorne, Alan R. (1985), "Indoor air quality: a researcher's perspective", Oak Ridge National Laboratory, Oak Ridge, TN 37831. DE85 061251 (6 pages).

KEYWORD: CH2O, CO, energy, smoking, health, home, microorganism, outdoor, NO2, odor, regulation, radon, research, VOC, combustion

The history, policy implications, and important pollutants associated with indoor air are presented for the layperson. The government's approaches to addressing the problem of outdoor air pollution and indoor air pollution are compared. The pollutants addressed include radon, CO, NO2, cigarette smoke, volatile organic compounds, formaldehyde, and microorganisms. The effects of energy conservation measures are also discussed. The paper concludes by calling for research into phenomenological aspects of indoor air pollution.

0524
Hawthorne, Alan R., and Matthews, Thomas G. (1984) "Formaldehyde: an important indoor pollutant", Oak Ridge National Laboratory, Oak Ridge, TN 37831 (8 pages). NTIS DE84-012331.

KEYWORD: CH2O, literature, control, health, source, home, VOC, exposure, multipollutant

This paper highlights the important issues relating to formaldehyde and indoor air quality, including health effects, sources, impact of environmental parameters, typical levels in residences, and possible remedial measures. Other organic pollutants are also mentioned briefly.

0636
Hayes, S.R., Seigneur, C., and Lundberg, G.W. (Aug. 1984) "Numerical modeling of ozone population exposure: an application to a comparison of alternative ozone standards", API Publication no. 4400, American Petroleum Institute, 1220 "L" St. NW, Washington, DC 20005 (98 pages).

KEYWORD: O3, methodology, QA, research, NEM, distribution, model, regulation, exposure, NAAQS, QA

This study investigates an alternative methodology for assessing O3 population exposure, under conditions characteristic of the attainment of alternative National Ambient Air Quality Standards (NAAQS) for O3. Los Angeles data were used to test the NAAQS Exposure Model (NEM) with the Urban Airshed Model (ASM). This NEM/ASM technique is efficient and more accurate than EPA's linear rollback method. NEM/ASM could be applied directly to the NEM data bases for other cities. Several other NEM refinements are possible.

0745
Hayward, S.B., Sexton, K., and Webber, L.M. (1984) "Application of automated particle analysis to indoor source apportionment", Paper no. 84-33.8, presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, (19 pages).

KEYWORD: methodology, source, particulate, home, office, aerosol, outdoor, sample, monitoring, multipollutant

This paper outlines the deficiencies of bulk chemical analysis in source apportionment methods and how these can be overcome by the automated application of electron microscopy with dispersive x-ray analysis. Automated particle analysis (APA) is applied to the source-receptor modeling method, which uses ambient measurements and data on individual emission sources to apportion contributions from various emission categories. The feasibility and suitability of using source-receptor techniques to apportion indoor aerosols have not been established. This paper discusses indoor monitoring results which indicate that APA holds promise for apportioning at least some of the particles found indoors. The authors cover sampling, sample preparation, automated electron microscopy, x-ray spectral processing, and the results in the form of particle classification.

0639
Helsing, Knud J., and Chapa, Thomas J. (1986) "A follow-up investigation of the health status of eighth grade students in three middle schools of Washington County, as reported by their parents", Johns Hopkins Training Center for Public Health Research, 615 N. Wolfe St., Baltimore, MD 21205 (19 pages).

KEYWORD: health, architecture, control, source, school, energy, ventilation, demographic

Substantial ventilation improvements were made in this school, as recommended by the original study (BLIS #638). A year later, both health complaints and signs of ill health at the Northern

Middle School in Hagerstown, MD, had declined to level near those of two similar schools. Continued attention to adequate ventilation seems essential.

0183
Helsing, K.J., Comstock, G.W., Meyer, M.B., and Tockman, M.L. (1982) "Respiratory effects of household exposures to tobacco smoke and gas cooking on nonsmokers", Environ. Int., 8:365-370.

KEYWORD: combustion, source, particulate, smoking, health, lung, demographic, literature, statistical, appliance

The records of 708 nonsmoking white adult residents of Washington County, MD, who had participated in two studies of respiratory symptoms were analyzed to evaluate the effects of exposure at home to two potential sources of indoor air pollution: passive smoking and gas cooking. After adjustment for the effects of age, sex, socioeconomic level, occupational exposure to dust, and years of residence in the household, the presence of one or more smokers in the household was only suggestively associated with a higher frequency of chronic phlegm and impaired ventilatory function. Gas cooking was associated with a significantly higher frequency of chronic cough and with a significantly greater percentage of impaired ventilatory function.

0181
Hernandez, Thomas L., and Ring, James W. (1982) "Indoor radon source fluxes: experimental tests of a two-chamber model", Environ. Int., 8:45-47.

KEYWORD: radon, model, source, home, architecture, ventilation, laboratory

Modeling houses as two coupled chambers, namely, the living area and the basement, predicts more accurately the total indoor radon source emissions flux from building materials and geologic sources than a one-chamber model in houses with disparate radon concentrations. Three regional surveys found mean radon concentration ratios between basement and living area to range from 1.4 to 4.2, implying weak interchamber coupling in most cases. The invariability of second-order system parameters under steady infiltration but different initial conditions confirms the adequacy of the two-chamber model. Presence of a characteristic source flux was detected within the basements of two houses, in one case across different infiltration, coupling, and initial conditions. One-chamber models fit to two-chamber tracer gas data in one house show a source flux variation of a factor of 6 across changing coupling, while the two-chamber source flux variation factor was 1.5. Much of the apparent one-chamber living-area source flux in these cases is variable convective radon flux from the basement. The technique is not sensitive enough to detect living-area source fluxes if either the interchamber coupling is strong or the basement source flux is substantially larger.

0159
Hess, C.T., Weiffenbach, C.V., and Norton, S.A. (1982) "Variations of airborne and waterborne Rn-222 in houses in Maine", Environ. Int., 8:59-66.

KEYWORD: radon, ventilation,activity, field, water, source, home, track-etching, exposure, activity

Concentrations of airborne radon ranging from 0.05 to 135 pico Curies/liter were found in houses in Maine. Track-etch cups were placed in five positions for 100 houses from October 1980 to May 1981 to determine integrated average radon concentrations. To investigate the association between elevated radon concentrations in well water and indoor airborne radon concentrations, the radon in the water supplies of these houses was measured by liquid scintillation. Monitors of airborne radon, recording at 10-minute intervals for 5 to 7 days, were used for dynamic studies in 18 houses to determine the component of airborne radon associated with major water uses (such as showers, laundry, and dishwashing), which liberate radon bursts. Residents kept logs noting the time of major water usage. For some of the houses, ventilation rates ranging from 0.3 to 2 air changes per hour were determined by analyzing the dynamic data. The component of airborne radon associated with water sources varied inversely with ventilation rate and directly with waterborne radon concentration.

0468
Hess, C.T., Fleischer, R.L., and Turner, L.G. (1985) "Field and laboratory tests of etched track detectors for 222Rn: summer-vs-winter variations and tightness effects in Maine houses", Health Phys., 49(1):65-79.

KEYWORD: radon, field, seasonal, monitoring, energy, ventilation, home, source, methodology, exposure

Effects of tightness of homes and of bedrock character on indoor radon-222 concentrations were studied in 70 homes in Maine by means of four 6- to 8-month-long surveys over 1.5 years. Laboratory experiments were also performed to document the reliability of the track-etching system used for the measurements. In this survey, the radon in tight homes averaged 3.5 times that in drafty ones, and homes located in areas with granitic bedrock had 2.3 times the radon as homes on chlorite-biotite-rich bedrock. Winter-to-summer ratios ranged from 0.5 to 7, and averaged 1.5, implying that surveys of individual homes require a full year of monitoring.

0536
Hess, C. Thomas, Weiffenbach, Conrad, and Nyberg, Phillip (1983) "Integrated radon data from dwellings in Maine and Texas", Health Phys., 45:428-432.

KEYWORD: radon, home, design, field, methodology, source, water, distribution, sampling, exposure, architecture

A preliminary analysis is presented of radon-222 surveys made in the summer and fall of 1980 in Houston, TX, and in the late fall and winter of 1980-81 in several communities in central Maine. Approximately 100 dwellings were surveyed in each area during the season when houses are most likely to be closed to control temperature. The primary objectives of the surveys were to (1) develop baseline data on the distribution of indoor radon concentrations in the two areas, (2) determine the extent of spatial variations within dwellings, (3) add to the understanding of source mechanisms, and (4) evaluate the utility and practicality of various air-sampling strategies. With the exception of four previously sampled structures in Maine, houses were selected for study with no direct knowledge of the radon content of the indoor air. The majority of the Maine houses had previously been involved in a survey of radon-222 in drinking water, and an effort was made to span the range of values noted in that project. The dwellings reflected the prevalent building styles in the two areas. Single-story slab-on-grade houses and two- or three-story apartment buildings predominated in Texas, while two-story wood frame houses with full or partial basements were most common in Maine. Questionnaires regarding a number of housing characteristics were administered during the study, the results of which will be used in subsequent analyses.

0589
Higgins, Millicent W. (1985) "Critical review of the relationship between passive exposure to cigarette smoke and cardiopulmonary disease", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 241-256.

KEYWORD: smoking, lung, epidemiology, methodology, exposure, QA, health

Nonmalignant pulmonary diseases and conditions have been associated with passive exposure to cigarette smoke in epidemiological and clinical studies. Evaluating these findings is difficult because evidence is inadequate and results are inconsistent; measures of passive smoking have usually been derived from available information on smoking habits of parents, spouses, or other associates of nonsmokers. Consequently, further well-designed studies of cardiopulmonary disease and passive smoking are needed, and they should include more precise objective measures of exposure.

0007
Hijazi, N., Chai, R., Amster, M., and Duffee, R. (1983) "Indoor organic contaminants in energy-efficient buildings", Frederick, Edward R., et al., Eds., "Proceedings of the specialty conference on measurement and monitoring of noncriteria (toxic) contaminants in air, held in March of 1983 ", Publication no. SP-50, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, pp. 471-477.

KEYWORD: energy, ventilation,,office,architecture,CH2O, nicotine, NH3, NOx, ketone, acetamide, amine, pyridine

This report outlines the findings of study of indoor organic contaminants in an energy-efficient building. The study used a portable mass spectrometer (SCIEX TAGA 3000) capable of direct analysis of head space and air bag samples without further extraction or processing. Degassing products from construction, insulation, furniture, and decorative materials were determined, and grab air bag samples were collected from various locations within the building and from the exhaust and intake of the ventilation system. The results indicated that numerous organic contaminants were being released from the materials as well as by human activity within the building. The following chemicals were selected for semiquantitative analysis: ethyl amine, propyl amine, butyl amine, pyridine, methyl pyridine, methyl vinyl ketone, methylbutyl ketone, dimethyl acetamide, nicotine, pyruvic acid, and lactic acid. The concentrations varied with the sampling location within the building. The exhaust and intake grab samples showed significant re-entrainment of the detected chemicals.

0160
Hildingson, O. (1982) "Radon measurements in 12,000 Swedish homes", Environ. Int., 8(1-6):67-70.

KEYWORD: radon,Sweden,microenvironment,home,exposure,ventilation, source,track-etching,methodology,regulation,foreign,architecture

Radon daughter levels were monitored in 12,000 Swedish dwellings in 1980-81. In 1979, the Swedish government introduced temporary limits for the radon daughter concentration in dwellings. For existing buildings, this limit is 400 Becquerels (Bq)/m3 or 0.11 Working Levels (WL). Two methods were used to monitor radon daughter concentration. Most of the houses were monitored using a track-etch detector; some houses were monitored using a filter-sampling technique while the ventilation rate was determined. Close to 15% of the investigated houses had a radon daughter concentration higher than 400 Bq/m3. Most of the high-level houses were one-family houses; almost 10% of this group had a concentration above 1,000 Bq/m3 (0.27 WL). This study shows that the two most important sources for radon in buildings are building materials and the ground.

0604
Hochheiser, Seymour, and Jayanti, R.K.M., Eds., (1986) "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (907 pages). Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: VOC, exposure,methodology, research, outdoor, home, QA, office, multipollutant, wood , source

A conference co-sponsored by the Air Pollution Control Association and EPA's Environmental Monitoring Systems Laboratory was held in Raleigh, NC, April 27-30, 1986. The technical program consisted of 95 presentations, held in 10 separate sessions, on the recent advances for measuring and monitoring toxic and other contaminants found in ambient and source atmospheres. Presentations included: (1) measurement of indoor toxic air contaminants; (2) measurement of semi volatile and volatile organic pollutants in ambient air; (3) chemometrics and environmental data analysis; (4) acidic deposition-nitrogen species methods comparison study; (5) measurement of hazardous waste emissions; (6) measurement of wood stove emissions; (7) source monitoring; and (8) general papers related to quality assurance and particulate measurements.

0381
Hoek, G., Brunekreef, B., Meijer, R., and Scholten, A. (1984) "Indoor NO2 and respiratory symptoms of Rotterdam children", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 227-232. NTIS PB85-104206.

KEYWORD: NO2, health, exposure, children, foreign, Netherlands, QA, lung

The relationship between indoor NO2 exposure and respiratory symptoms of school children was investigated in a case-control study. No association was found between indoor NO2 and respiratory symptoms. The study population appeared to have been highly mobile in the past, making it impossible to furnish reliable estimates of historical exposure. Therefore, the results do not disprove the possibility of an association between indoor NO2 exposure and respiratory symptoms.

0418
Hoffman, Mary (May 1986) "Bibliography on indoor radon", IMSD/86-002, U.S. EPA, Information Services and Library, Washington, DC 20460 (100 pages). Not available from NTIS.

KEYWORD: radon, model, source, home, control, methodology, water, personal, health, exposure, ventilation, literature, EPA$

Citations for this bibliography were compiled from pertinent online data bases and selected because of their relevance to EPA's radon program. The bibliography focuses on indoor radon pollution problems and is organized according to the following major topics: (1) general articles on radon, (2) contributing factors, (3) ventilation and energy efficiency, (4) radon in water, (5) measurement and modeling, (6) mitigation of the problem, and (7) health effects of radon. Many of the citations have descriptive abstracts, and an appendix lists contacts for further information.

0365
Hoffmann, D., Brunnemann, K.D., Adams, J.D., and Haley, N.J. (1984) "Indoor air pollution by tobacco smoke: model studies on the uptake by nonsmokers", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 313-318. NTIS PB85-104198.

KEYWORD: CO, HCN, NOx, CH2O, nicotine, particulate, smoking, exposure, biomonitoring

For a small room (16 m3) continuously polluted with sidestream smoke from two, three, or four cigarettes, the highest pollution levels recorded were: CO, 25 ppm; NOx, 0.91 ppm; hydrogen cyanide, 56 ug/m3; formaldehyde, 1.6 ug/m3; nicotine, 288 ug/m3; and particulate matter, 4,600 ug/m3. During each session, the nonsmokers stayed in the room for 80 minutes. Saliva, blood, and urine samples were collected before, during, and 5 hours after exposure and were analyzed for nicotine, cotinine, and thiocyanate. Blood was analyzed also for carboxyhemoglobin. The highest levels of nicotine or cotinine in the physiological fluids of the nonsmokers did not exceed 3% of the mean per person recorded for 450 smokers of more than 20 cigarettes/day. Nitrosoproline in urine serves as an indicator for endogenous nitrosamine formation on exposure to nitrosating agents. First data after exposure to passive smoke do not indicate increased urinary excretion of nitrosoproline.

0135
Holland, David M. (Aug. 1983) "CO levels in microenvironment types in four U.S. cities", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (30 pages). Not available from NTIS.

KEYWORD: personal, exposure, monitor, vehicle, interior, field, CO, outdoor, microenvironment, EPA$

Portable monitors were used to measure time-averaged (10 to 30 minutes) personal exposures to CO. Data were collected from January through March 1981 in four cities where ambient CO levels in excess of National Ambient Air Quality Standards (NAAQS) have been reported: Stamford, CT, Los Angeles, CA, Phoenix, AZ, and Denver, CO. In each city, personal exposures were measured in three common microenvironments (indoor, commuting, and residential driving) near fixed stations monitoring ambient CO. Measurements recorded at urban and urban-residential monitoring stations (excluding one station in Stamford) underrepresented the time-weighted mean of commuting and residential driving exposures by factors of 0.4 to 0.7. Fixed monitoring stations in Los Angeles, Phoenix, and one station in Stamford overrepresented the time-weighted mean of indoor exposures by factors of 1.1 to 1.3. However, in Denver and another station in Stamford, urban stations underrepresented the mean of indoor exposures by factors of 0.4 to 0.8. Regressing personal exposures on concurrent fixed-site concentrations for all recorded values revealed no conclusive linear relationships.

0006
Holland, David, and Mage, David T. (1983) "Carbon monoxide concentrations in four cities during the winter of 1981", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (74 pages). NTIS PB83-224907.

KEYWORD: CO, field, vehicle, interior, outdoor,personal,exposure, microenvironment, monitor, EPA$

Field studies are described covering time-averaged exposures (10 to 30 minutes) to CO in Los Angeles, CA, Phoenix, AZ, Denver, CO, and Stamford, CT, in the winter of 1980-81. Technicians carried personal exposure monitors in three common microenvironments (indoors, commuting, and residential driving) to record the actual exposures people receive. The highest indoor exposures were observed in Denver (arithmetic mean of 6.1 ppm), and the highest commuting and residential driving exposures were recorded in Los Angeles (11.4 ppm and 7.6 ppm, respectively). Relationships between personal exposures and simultaneous fixed-station measurements were not linear.

0661
Hollowell, Craig, D., and Miksch, Robert R. (Dec. 1981) "Sources and concentrations of organic compounds in indoor environments", Bull. N.Y. Acad. Med., 57(10):962-977.

KEYWORD: source, exposure, EPA$, CO2, humidity, combustion, CO, CH2O, radon, NO2, particulate, VOC, energy, home, ventilation

This paper discusses the sources and indoor and outdoor concentrations of formaldehyde and other volatile organic compounds. Outdoor sources include industries, vehicles, and organisms. Indoor sources include building and furniture materials, appliances, water, smoking, human metabolism, and a wide variety of household consumer products. Health and regulatory issues are reviewed, and possible control measures, such as ventilation, are suggested.

0383
Holmberg, Kenneth (1984) "Mould growth inside buildings", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 253-256. NTIS PB85-104206.

KEYWORD: microorganism,exposure,methodology,sampling, particulate

Mold growth inside buildings merits study both in its own right as a natural phenomenon, and because it easily becomes airborne and might pose a health problem for certain individuals. The numbers and types of airborne mycoflora inside buildings depend on air exchange with the outside and the presence of an endogenous mold population. Without intramural mold sources, indoor mold spore levels, to a major degree, reflect outdoor levels. Endogenous mold growth may significantly change the types of mold present or their concentrations. Indoor sampling efforts confront an array of problems. An accurate assessment of the total mold exposure inside buildings requires refinement in the sampling procedures to avoid inadequacies of traditional approaches.

0471
Holub, R.F., et al. (1985) "Radon-222 and 222Rn progeny concentrations measured in an energy-efficient house equipped with a heat exchanger", Health Phys., 49(2):267-277.

KEYWORD: radon, field, monitoring, ventilation, exposure, home, methodology, source, pressure, energy, architecture

Radon-222 and radon-222 progeny concentrations, barometric pressure, and pressure differentials between inside and outside were measured continuously in the basement of a recently constructed energy-efficient house in metropolitan Denver, CO. Although the monitoring equipment was developed primarily for underground mines, it proved to be applicable for house monitoring. Results indicate that, for tightly sealed houses, forced-flow transport does not significantly contribute to the radon-222 that is present even when the pressure within the house is less than the outside pressure by 0.8 Pa (0.006 mm Hg). Calculations of radon-222 levels using diffusion as the primary transport mechanism agreed with observed data. The diffusion coefficient of radon-222 in the walls and floor surrounding the basement is higher than values previously reported. Ventilation by means of a heat exchanger reduces the radon-222 levels in accordance with measured air exchange rates, regardless of the pressure differential between inside and outside.

0499
Hov, Oysteln, and Larssen, Stelnar (1984) "Street canyon concentrations of nitrogen dioxide in Oslo: measurements and model calculations", Environ. Sci. Technol., 18(2):82-87.

KEYWORD: NO2, outdoor, field, vehicle, source, model, foreign, seasonal, Norway

Hourly mean concentrations of NO2 in excess of the frequently quoted exposure limit of 190 to 320 ug of NO2/m3 (95 to 160 ppb) have repeatedly been recorded in a street in Oslo, Norway, during the winter. In January 1981, the hourly mean concentrations exceeded 200 ppb on 7 days; the maximum was 270 ppb. Summer concentrations were much lower. With a simple model of the combined effect of chemistry and dilution of the exhaust gas plume, it was shown that NO2 generation through the reaction NO + NO + 02 --> 2NO2 may explain a small fraction of the NO2 formation. The study indicated that typically 5 to 10% of street-level NOx can be taken as NO2 formed through this reaction. To account for the NO2 measured, the authors suggest that the NO2 fraction of NOx in car exhaust may be higher in the driving conditions found in Oslo during the winter than what is recorded in the standard for testing car exhaust emissions.

0320
Howes, J.E., Jr., Vijayakumar, R., Doerfler, F., Burmann, F.J., and Howard, F.S. (Aug. 1985) "Preliminary evaluation of a modified NBS PM 10 sampler for indoor particulate measurements", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (39 pages). NTIS PB85-2470057/AS.

KEYWORD: particulate, personal, exposure, monitor, EPA$,sampling, field, QA, outdoor

The prototype National Bureau of Standards PM10 portable sampler has been modified to overcome several design flaws. The modifications included replacing the case, redesigning the filter holder, and adding a motor control circuit. The performance of an indoor air sampler developed by Harvard University was also evaluated in this study. Both samplers yielded PM10 data comparable to that obtained with a conventional ambient-type dichotomous sampler.

0366
Hugod, Carl (1984) "Passive smoking -- a source of indoor air pollution", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 319-325. NTIS PB85-104198.

KEYWORD: NO2,HCN,acrolein, aldehyde, exposure, CO, biomonitoring, smoking, laboratory

In a tightened room of approximately 60 m3, side-stream cigarette smoke was maintained at a constant level of approximately 20 ppm during a 3-hour experiment. Air concentrations of CO, NO2, hydrogen cyanide, acrolein, and other aldehydes were measured with and without people present. These tobacco smoke constituents were encountered in lower concentrations with, than without, people present. Carboxyhemoglobin concentration was not a good general indicator for exposure to tobacco constituents. Subjective discomfort, estimated in questionnaires distributed every 30 minutes during the experiment, was at almost identical levels irrespective of exposure to whole side-stream smoke or to the gas phase of the smoke. Exposure of volunteers to acrolein caused considerably less discomfort than exposure to whole side-stream smoke or to the gas phase.

0621
Humphreys, M.P., Knight, C.V., and Pinnix, J.C. (1986) "Residential wood combustion impacts on indoor carbon monoxide

and suspended particulates", Hocheiser, S. and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 736-747. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: wood, field, home, exposure, CO, PAH, energy, source, ventilation, combustion, NO, particulate

Recent studies conducted by Tennessee Valley Authority during the winters of 1983, 1984, and 1985 have evaluated the impacts of both airtight (catalytic and conventional) and non-airtight wood heaters on indoor air quality in a weatherized home. CO and suspended particulate results for the three studies are presented in this paper. Depending on the operating conditions, the wood heaters were found to represent a major source of indoor CO and suspended particulates. Several other pollutants (NO and polynuclear aromatic hydrocarbons) were also found to be associated with residential wood combustion.

0431
Iachan, R., Pate, D.K., Sebestik, J., and Whitmore, R.W. (1986) "Final report on focus groups used to refine the survey design for the National Indoor Air Quality Study", Contract no. 68-01-6826, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (29 pages).

KEYWORD: EPA$, exposure, CO2, NOx, VOC, CH2O, CO, radon, source, methodology, home, design, particulate, combustion

EPA's National Indoor Air Quality Study is designed to estimate the distribution of concentrations of volatile organic compounds (VOCs), combustion products, and respirable particulates in U.S. homes. EPA conducted meetings (focus groups) with residents of Durham, N.C. during October of 1986 to determine how households decide whether or not to participate in such a study and also how to maximize their participation. The greatest incentive to participate in such a study is curiosity about the results. Discouraging factors include noisy and/or bulky monitoring equipment, complicated activity diaries, and unclear or redundant prose in information packets.

0154
Ingalls, Melvin N. (March 1984) "Mobile source exposure estimation", U.S. EPA, Office of Mobile Source Air Pollution Control, Ann Arbor, MI 48105 (150 pages). NTIS PB84-224518.

KEYWORD: CO, model, NEM, source, vehicle, outdoor, literature, exposure, EPA$, microenvironment

This project was conducted to provide the nationwide annual person-hours of exposure to mobile-source pollutants. The first activity was to determine the suitability of the National Ambient Air Quality Standards (NAAQS) Exposure Model (NEM), as used in a study of CO ambient standards, to estimate mobile-source exposure. By itself, the NEM CO study did not adequately estimate mobile-source exposure. However, the NEM with modified inputs could be used for CO with a mobile-source microenvironment exposure model to produce the desired exposure estimates. NEM can be thought of as a "people-specific" model, because it follows groups of people through their daily activities. The mobile-source microenvironment exposure model developed for this project is a "place-specific" model. It calculates exposure for a given place and time and is not concerned with where the people are before of after their stay in the microenvironment. Exposure in four microenvironments was examined: parking garages, street canyons, expressways, and roadway tunnels. For these microenvironments, data on concentrations of CO from mobile sources were obtained from EPA data bases. The nationwide population of these microenvironments for each hour of the day was obtained from the published literature. Results of the modified NEM can be combined with the data from this study to obtain the nationwide exposure estimate for a pollutant.

0039
Ingalls, Melvin N. (July 1981) "Estimating mobile source pollutants in microscale exposure situations", U.S. EPA, Office of Mobile Source Air Pollution Control, Ann Arbor, MI 48105 (182 pages). NTIS PB82-101114.

KEYWORD: vehicle, source, outdoor, literature, microenvironment, model, EPA$

Methods are described for estimating the concentration of any vehicle-generated air pollutant in areas where people and vehicles are in close proximity. For each of several microscale locations where people ordinarily are found, the appropriate dispersion model is described. Physical data are presented on residential garages, parking garages, roadway tunnels, street canyons, and expressways in the U.S., and a variety of models and other pertinent information are included.

0115
Ingalls, Melvin N. (July 1981) "Estimating concentrations of mobile source pollutants in a variety of exposure situations", Final report, U.S. EPA, Office of Air and Waste Management, Ann

Arbor, MI 48105 (121 pages). NTIS PB82-101114.

KEYWORD: model, microenvironment, statistical, source, exposure, dose, vehicle, EPA$

This report classifies situations involving exposure to mobile-source pollutants, presents mathematical models for predicting short-term exposures in each situation, and uses the models to predict exposures in hypothetical examples of each situation. Work not yet done includes selection and refinement of additional models and further definition of physical parameters of "real world" exposure situations (e.g., enclosed spaces, street canyons, expressways, small-area sources). The final product, a total dose computer program, will compute the short-term pollutant dosage for each situation and the total dosage for all scenarios.

0040
Ingalls, Melvin N., and Garbe, Robert J. (June 1982) "Ambient pollutant concentrations from mobile sources in microscale situations", Technical paper mo. 820787, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096 (16 pages).

KEYWORD: vehicle, source, literature, model, microenvironment, methodology, exposure, EPA$

A method was developed for estimating concentrations of vehicle-generated pollutants where people and vehicles are in close proximity. A list of common exposure situations is extracted from hypothetical daily activity routines. For each situation, an appropriate dispersion model is selected. The range of real-world physical variables for each situation is examined. From this range, typical and severe actual situations are chosen. Pollutant concentrations are calculated for each typical and severe situation using the appropriate dispersion model. Emission factors of 1 gram/mile or minute are used to facilitate scaling.

0054
Jabara, J.W., Keefe, T.J., Beaulieu, H.J., and Buchan, R.M. (1980) "Carbon monoxide: dosimetry in occupational exposures in Denver, Colorado", Arch. Environ. Health, 35:198-204.

KEYWORD: CO, field, personal, industrial,seasonal, biomonitoring, exposure, smoking, sampling, source

Exposure of Denver, CO, traffic control personnel to CO was evaluated during 8-hour work shifts using three parameters: (1)

98 9-hour time-weighted average breathing zone air samples (personal dosimetry), (2) before- and after-work shift CO breath samples, and (3) 8-hour moving-average ambient CO levels during the fall and winter months. Different shifts and work experiences were taken into consideration. The data reveal greater CO exposures in subjects working on streets than controls working inside downtown buildings with respect to breath-CO samples and breathing-zone-air samples. CO concentrations in after-work shift breath samples were closely associated with 8-hour time-weighted average CO levels. The greatest source of CO to the sample population was cigarette smoking, followed by occupationally related sources, and finally, ambient background CO levels.

0296
Jackson, M.D., and Lewis, R.B. (July 1981) "Insecticide concentrations in air after application of pest control strips", Bull. Environ. Contam. Toxicol., 27(1):122-125.

KEYWORD: pesticide, propoxur, chlorpyrifos, field, VOC, diazinon, sampling, source, home

A study was designed to determine how much, if any, pesticide gets into the air of a room with properly applied pest control strips. Pest control strips of varying concentrations of different insecticides were placed in a room according to the manufacturers' recommendations. Air samples were collected and analyzed. The highest air concentrations found were 0.8, 1.4, and 0.25 mg/m3 from propoxur, diazinon, and chlorpyrifos, respectively.

0300
Jackson, M.D., and Wright, C.G. (May 1975) "Diazinon and chlorpyrifos residues in food after insecticidal treatment in rooms", Bull. Environ. Contam. Toxicol., 13(5):593-595.

KEYWORD: diazinon, chlorpyrifos, food, pesticide, home

Residual diazinon and chlorpyrifos were measured in foods in a room at the time of treatment with insecticides and in foods placed in treated rooms after treatment. A person consuming a TV dinner at the highest residue found would ingest 0.015 mg diazinon.

0663
Jaeger, Rudolph J. (Dec. 1981) "Carbon monoxide in houses and vehicles", Bull. N.Y. Acad. Med., 57(10):860-871.

KEYWORD: CO, health, biomonitoring,smoking, outdoor,vehicle,home, control,exposure,source,microenvironment,combustion,appliance

CO is produced indoors mainly by tobacco smoking and unvented gas appliances. Concentrations of carboxyhemoglobin (COHB) in human blood range from less than 1% in nonsmokers to 5-10% in smokers. In fetuses of smoking mothers, as much as 7.6% COHB has been found. The adverse health effects of these exposures in children may be substantial, and unvented indoor combustion should be discouraged.

0359
Janka, K., and Kulmala, V. (1984) "Optical particle counter as a wide range, continuous monitor for particle concentrations", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 215-219. NTIS PB85-104198.

KEYWORD: particulate, methodology, QA,monitoring,exposure

The researchers have modified a Royco 218 particle counter for continuous monitoring indoors. The modifications consist of making slight alterations in the flow system and adding electronics, including an improved base-line restorer and a dual-channel ratemeter that can be connected to a strip-chart recorder or to a data logger with analog inputs. The ratemeter has a coincidence-error correction system extending the measurable concentration range.

0180
Janssen, J.E., Hill, T.J., Woods, J.E., and Maldonado, E.A.B. (1982) "Ventilation for control of indoor air quality: a case study", Environ. Int., 8:487-496.

KEYWORD: CO2, ventilation, monitoring, model, control, energy

Dilution of contaminated indoor air with less-contaminated outdoor air is the most common strategy to control indoor air quality. Unfortunately, this strategy frequently wastes energy. A test was carried out in a school music department to obtain air quality, energy, and subjective response data. A control system with both CO2 and temperature inputs was devised to control the use of outdoor air. Infiltration measurements led to a quantitative measure of ventilation efficiency. The measured ventilation efficiency allowed validation of energy and CO2 models with measured data. Energy savings of approximately 20% were found for this application.

0522
Jarke, Frank H., and Gordon, Sydney M. (1981) "Recent investigations of volatile organics in indoor air at sub-ppb levels", Paper no. 81-57.2, presented at the 74th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: VOC, source, methodology, exposure, dose, biomonitoring, sampling, laboratory, monitoring

The development of a suitable technique for surveying indoor environments for a wide range of volatile organic compounds of different chemical classes, molecular-weight ranges, and concentrations would afford scientists the opportunity to explore such items as (1) long-term chronic exposure, (2) episodic exposure, (3) body-burden studies, and (4) headspace analysis of isolated sources such as building materials, cooking operations, duplication machines, and various other potential sources. The methodology described covers two types of preconcentration collectors. One is more suitable for grab sampling and investigation of the dynamics of indoor pollutants, while the second is an integrating type and is more suited to average exposure studies. The differences between these two collection modes are the sampling time and the quantity of porous polymer used. These collectors have evolved to their present configuration after more than 15 years of experience with vapor concentration.

0668
Jarvis, M., Tunstall-Pedoe, H., Feyerabend, C., Vesey, C., and Salloojee, Y. (1984) "Biochemical markers of smoke absorption and self reported exposure to passive smoking", J. Epidemiol. Commun. Health, 38:335-339.

KEYWORD: CO,methodology,biomonitoring,smoking,activity, exposure, nicotine,field,foreign,dose,Britain,cotinine,thiocyanite

One hundred nonsmoking hospital outpatients in London, England, reported their passive exposure to tobacco smoke over the preceding three days and provided samples of blood, expired air, saliva, and urine. Although the absolute levels were low, the concentration of cotinine in all body compartments surveyed was linearly related to the reported exposures. For saliva, this relationship held true only for exposure on the day of the test. CO, thiocynate, and plasma nicotine were unrelated to exposure. Cotinine provides a valid marker of the dose received from passive smoking.

0628
Jewell, Richard A. (1980) "Reduction of formaldehyde levels in mobile homes", Paper presented at the symposium, "Wood sdhesives - research, applications, and needs," Madison, WI, September 23-25, 1980 (7 pages). NTIS ADP-002-426.

KEYWORD: control, economic, CH2O, method, odor, source, wood, ventilation, home, regulation

This preliminary report on investigations into methods of reducing airborne formaldehyde levels in mobile homes identified two effective techniques. Fumigation with ammonia appears to produce long-term reductions of approximately 61 to 73%. A high-capacity air recirculation device that removed formaldehyde by a filter bed of potassium-permanganate-impregnated alumina pellets reduce levels by apporximately 74% during operation. The report also discusses variables affecting formaldehyde levels, and ineffective products on the market. Ammonia fumigation is cited as the most cost-effective approach to reducing formaldehyde levels.

0480
Johansson, Ingegerd (1978) "Determination of organic compounds in indoor air with potential reference to air quality", Atmos. Environ., 12:1371-1377.

KEYWORD: school, hydrocarbon, sampling, field, foreign, Sweden, VOC, outdoor, aromatic, exposure, acetone

Concentrations of 15 volatile organic compounds were investigated in the air of two Swedish schoolrooms. The chemical analysis included enrichment on porous polymer beads, heat desorption, and gas chromatographic separation on a capillary column connected to either a flame-ionization detector or a mass spectrometer. Samples were collected from the indoor air both in the presence and in the absence of the pupils, as well as from ambient outdoor air. In both indoor and outdoor air, aliphatic and aromatic hydrocarbons predominated, although the number of compounds detected indoors was larger and the concentrations higher. Both the number and the concentration increased in the presence of humans. The mean concentrations of acetone and the sum of the concentrations of C2-alkylbenzenes were 7.7 and 8.2 ug/m3 respectively, in an unoccupied room and increased to 19.8 and 12.1 ug/m3 respectively in an occupied room.

0556
Johnson, Clark (1986) "A reaction to Repace and Lowrey (1985)", Environ. Int., 12(1-4):21-22.

KEYWORD: smoking, methodology, health, exposure, literature, QA, model, risk, statistical, demographic, lung, exposure

This letter to the editor is highly critical of the methodology used by Repace and Lowrey for the journal's 1985 article: "A quantitative estimate of nonsmokers' lung cancer risk from passive smoking" (BLIS #86). Specifically, Johnson argues that the authors (1) miscalculated and inflated the numbers of cigarettes smoked, (2) used a faulty theoretical model to overestimate nonsmokers' exposures, and (3) may have misapplied their model's formula. This tendency to inflate the magnitude of passive smoking invalidates their estimate of 5,000 additional lung cancer deaths because of passive smoking. Repace and Lowrey rebut these arguments in BLIS #559.

0043
Johnson, T., and Paul, R.A. (1984) "The NAAQS Exposure Model (NEM) applied to carbon monoxide", U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711 (234 pages). NTIS PB84-242551.

KEYWORD: CO, model, exposure, NAAQS, NEM, EPA$

The neighborhood version of the National Ambient Air Quality Standard (NAAQS) Exposure Model (NEM) is used to compute CO exposures of the population of four urban areas (Chicago, IL, St. Louis, MO, Philadelphia, PA, and Los Angeles, CA). The model estimates exposures associated with alternative NAAQS values proposed for CO. Results of these analyses and the contribution of indoor CO to total population exposures are evaluated.

0726
Johnson, T.R. (1984) "A study of personal exposure to carbon monoxide in Denver, Colorado", Paper no. 84-121.3, presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (17 pages).

KEYWORD: smoking,activity, CO,personal, microenvironment,outdoor, exposure, methodology, source, combustion

Fixed-site monitoring data may not accurately indicate personal exposure within an urban population. Better estimates of personal exposure can be developed by equipping a large number of subjects with personal exposure monitors (PEMs) and activity diaries. If the subjects are properly selected, their exposures can be extrapolated to the larger urban population. Such a study on CO was conducted in Denver, CO, on 454 subjects for two consecutive 24-hour sampling periods. Each participant provided a breath sample at the end of each sampling period and also completed a detailed background questionnaire. The questionnaire results, and approximately 900 subject-days of exposure and activity diary data collected between November 1, 1982, and February 28, 1983, were analyzed to determine if factors such as microenvironment and the presence of indoor CO sources significantly affect personal CO exposure. In addition, the exposure of the entire Denver population was extrapolated from exposures of the participants. CO levels recorded by fixed-site monitors were compared to levels recorded simultaneously by PEM's. CO exposures in microenvironments associated with motor vehicles are higher than exposures in microenvironments not associated with motor vehicles. CO exposures in the microenvironments defined for this study are not strongly correlated with CO concentrations simultaneously recorded at fixed-site monitors. Indoor residential exposures are increased by gas stoves, smokers, and attached garages. The study provides a data base that should prove invaluable in answering questions concerning the factors which affect exposure, the ability of fixed-site data to represent personal exposures, the performance of new instruments, and similar issues.

0124
Johnson, Ted (Jan.1984) "A study of personal exposure to carbon monoxide in Denver, Colorado", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (272 pages). NTIS PB84-146125.

KEYWORD: CO, distribution, personal, exposure, monitor, activity, smoking, QA, microenvironment, EPA$, appliance, field

The target population for the study included all noninstitutionalized, nonsmoking residents of the urbanized portion of the Denver, CO, metropolitan area aged 18 to 70 years at the time of the study. A total of 454 study participants was obtained through the use of a screening questionnaire administered to several thousand households in the study area. Each participant carried a personal exposure monitor and an activity diary for two consecutive 24-hour sampling periods and provided a breath sample at the end of each period. Each participant also completed a detailed background questionnaire. CO exposures were higher in microenvironments associated with motor vehicles such as parking garages and automobiles. Mean indoor residential exposure was increased 2.59 ppm by gas stove operation, 1.59 ppm by the presence of smokers, and 0.41 ppm by attached garages. The population distribution of CO exposure is compared to the National Ambient Air Quality Standards.

0130
Johnson, Ted, Capel, Jim, and Wijnberg, Luke (Feb. 1985) "Selected data analyses relating to studies of personal carbon monoxide exposure in Denver and Washington", Contract No. 68-02-3496, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (196 pages). Not available from NTIS.

KEYWORD: CO, field,activity,outdoor, personal, exposure, monitor, statistical, model, smoking, source, EPA$, distribution

For a study of personal exposure to CO in Denver, CO, the target population included all noninstitutionalized, nonsmoking residents of the urbanized portion of the metropolitan area between the ages of 18 and 70 years. A total of 454 study participants was obtained through the use of a screening questionnaire administered to several thousand households in the study area. Each participant carried a personal exposure monitor (PEM) and activity diary for two consecutive 24-hour sampling periods and provided a breath sample at the end of each period. Each participant also completed a detailed background questionnaire. A similar study was conducted in Washington, DC. The Denver fixed-site data suggest that ambient CO levels decrease with increasing wind speed. Five monitors in the central business district reported daily maximum 8-hour concentrations exceeding 15 ppm. Linear regression analyses relating PEM values to Washington fixed-site readings yielded R-squared values exceeding 0.15 for eight microenvironments: indoors-hospital (0.65), indoors-church (0.60), indoors-garage (0.19), outdoors-park (0.15), train/subway (0.61), jogging (0.30), truck (0.27), and bicycle (0.16). Microenvironments found to be above the 8-hour National Ambient Air Quality Standard (9 ppm) included service stations, public garages, restaurants, outdoor locations within 10 yards of roads with high ambient CO, and trips beginning or ending in an area of high ambient CO. A model was developed that explained 34% of the variation in Denver PEM values. Daily maximum 8-hour exposures reported on consecutive days by Denver subjects were not highly correlated (R-squared = 0.16). PEM performance is discussed.

0535
Johnson, W.B., and Bailey, P.G. (August 1983) "Study of radon daughter concentrations in Polk and Hillsborough Counties", Health Phys., 42:432-435.

KEYWORD: activity, architecture, radon, source, exposure, field, control, phosphate, home, track-etching

In 1975, EPA stated that structures built on reclaimed phosphate land have radon daughter levels significantly greater than structures not built on reclaimed land. As a result, a study was begun in Polk and Hillsborough counties, Florida, examining a large number of structures with a potential for elevated radon daughter levels. The study, proposed to measure γ exposure rates and working levels inside homes built on undisturbed-nonmineralized, undisturbed-mineralized, and reclaimed land. If time allowed, researchers also planned to adapt and test some of the proposed control technologies. The sample studied included 1,000 homes of varying construction types and occupant living styles. Track-etch (TE) dosimeters were deployed in all of the homes, and about 200 of the homes also had a thermoluminescent dosimeter attached to the TE card. Working level was measured indirectly by the TE or directly by integrating radon daughter samplers. Many of the parameters for each site (i.e., land type, construction type, living style) were coded for ease of data manipulation and for assistance in pattern recognition.

0026

Johnson, T., and Paul, R. (May 1984) "NAAQS exposure model (NEM) applied to nitrogen dioxide", draft report under Contract no. 68-02-3390, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, (71 pages). Not available from NTIS.

KEYWORD: NO2, model, distribution, NEM, EPA$, regulation

The exposure version of the National Ambient Air Quality Standards (NAAQS) Exposure Model (NEM) is used to simulate the pollutant concentrations expected to occur in selected exposure districts within a study area under user-specified regulatory scenarios. These estimates are adjusted to account for an exhaustive set of microenvironments and typical movements through the districts, and microenvironments of population subgroups are simulated. Outputs of the simulation program are population exposure estimates at specified pollutant levels.

0161

Jonassen, Niels, and McLaughlin, J.P. (1982) "Air infiltration and radon daughter levels", Environ. Int., 8:71-75.

KEYWORD: radon, control, method, aerosol, health, lung, model, dose, exposure

The authors investigated the effect of filtration and aerosol loading of the air on the level of short-lived airborne daughter products of radon. With a combination of filtration and aerosol loading, it is possible to shift the partitioning of the radon daughters in the room between these states: airborne, plated-out on the walls, and trapped by filters. The airborne fraction shifts between being attached to aerosol particles and existing as molecular-sized clusters. When the air is filtered, the equilibrium factor decreases with increasing filtration rate. At a given radon concentration, the dose delivered to a certain portion of the respiratory tract depends not only on the equilibrium factor but also on the fraction of polonium-218 in the unattached state. The authors demonstrated that, according to the dose model of Harley and Pasternak, the dose to the basal cells of the epithelium of the bronchii will, in general, decrease with increasing filtration rate and increase with decreasing aerosol concentration.

0231
Jungers, R.H. and Howie, S.L. (May 1982) "Exposure to perchloroethylene associated with the use of coin-type dry cleaning machines", Published in "Proceedings: National symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982", pp. 153-156. NTIS PB84-148345.

KEYWORD: exposure, PERC, industrial, home, EPA$, dry-cleaner

Nearly all coin-type dry cleaners use perchloroethylene (PERC) as the cleaning solvent. EPA sponsored research to obtain data on public exposure to PERC that may result from dry cleaning in these self-service cleaners. Testing at a laundry facility and at an apartment located above the facility was conducted in Washington, DC. Indoor PERC levels varied in the range of from 90 to 14,000 ppb. PERC levels in the apartment were practically identical to those in the laundry facility below.

0050
Jungers, Robert H. (1983) "Recent advances in EPA's monitoring and methods development research", U.S. EPA, Environvental Monitoring Systems Laboratory, Research Triangle Park, NC 27711. NTIS PB83-231209.

KEYWORD: PAH,CO,VOC,vehicle,source,literature, sampling,personal, exposure, monitor

Several areas of advanced research related to sampling, analysis, and human exposure assessment of exhaust emissions in ambient air have been developed. These include studies of new methods for volatile organic compounds and development and application of personal exposure monitors in screening for polyaromatic hydrocarbons (PAHs) and CO. The new methods for screening PAHs are fast, economical, and accurate. The more expensive and time-consuming traditional method of analysis may be judiciously applied to those samples which the screening methods indicate are high in PAHs. CO was measured using personal exposure monitors in urban-scale studies to obtain data on population exposures on a real-time basis. Such data may ultimately be used in assessing human exposure to mobile sources and other emissions more accurately.

0326
Jungers, R.H., Akland, G.G., and Sauls, H.B. (1985) "A human exposure assessment study using personal monitoring of carbon monoxide--direct and indirect methods", Environ. Int., 11:413-418.

KEYWORD: CO, field,exposure,methodology, EPA$, personal,exposure, monitor, distribution

Residential exposure assessments have been based on the likely occurrence of an air pollutant when residential demographic data were merged with pollutant concentrations observed at the nearest fixed monitoring site. The recent development of personal exposure monitors (PEMs) enables measuring a person's total exposure in both ambient and indoor air. This paper introduces two approaches to determine CO exposure and describes the experimental data obtained. One is the direct approach in which a representative sample of the population is selected and sampled using a PEM. The indirect approach is the combination of field data from activity patterns and measured concentrations within microenvironments. The conclusions combine statistical survey design techniques and PEM concentration data to produce an exposure profile for a representative population.

0290
Jurinski, Neil B. (Aug. 1984) "The evaluation of chlordane and heptachlor vapor concentrations within buildings treated for insect pest control", Berglund, B., Lindvall, T. and Sundell, J., Eds. "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 51-56. NTIS PB85-104214.

KEYWORD: chlordane, heptachlor, pesticide, personal, exposure, field, home

Residual levels of chlordane and heptachlor insecticides in indoor air were determined following their use in residences. Analyses consistently found higher vapor concentrations of heptachlor than chlordane. However, for surface concentrations, chlordane levels were typically twice those of heptachlor. Instances were found in which the insecticide air concentrations exceeded the limits recommended by the National Academy of Sciences.

0527
Kahn, T.R., Meranger, J.C., and Lo, B. (1983) "Development of a prototype active personal monitor for SO2, NO2, and airborne particles", in Proceedings of national symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 315-332. NTIS PB84-148345.

KEYWORD: SO2, NO2, particulate, personal, exposure, monitor, QA, health, methodology, sampling

To relate exposure estimates to the likelihood of human health effects, it is necessary to monitor personal exposure to indoor air pollutants, such as NO2, SO2, and airborne particles. No dosimeter for monitoring personal exposure to these pollutants is currently available or is likely to be produced commercially in the near future. Certain promising devices were found, however. These either measured only one of the pollutants (Harvard/Electric Power Research Institute) or did not have the required sensitivity or operational life required (Gage Research Institute). The researchers initiated a project intended to assemble a prototype personal dosimeter from the most promising commercially available air pump, a solid sorbent media of the desired collection properties for NO2 and SO2, and an H&H cyclone with a Teflon filter for collecting size-selected particles. Five candidate pumps were chosen primarily on the basis of results from an earlier study on personal dosimeters for SO2, NOx, O3, and particulates. The Geomet, Inc. respiration-controlled sampler was not chosen because of its inherent flow variability. The Gage pump was excluded from further testing because it failed to deliver the target sampling rate of 2 liters/min. Two sorbents, triethanolamine-impregnated silica gel and molecular sieve, were tested for collecting NO2 and SO2. The results of these investigations and the prototype finally assembled are described.

0377
Kalinic, N., Sega, K., and Sisovic, A. (1986) "Formaldehyde levels in selected indoor microenvironments", Environ. Int., 12(1-4):297-299.

KEYWORD: CH2O, microenvironment, office, home, school, vehicle, exposure, sampling, laboratory, architecture

In 1983, formaldehyde concentrations in air were measured for 6 to 12 days in 12 rooms in 6 office buildings, in 9 sitting rooms and 2 kitchens in 9 apartments, in 10 kindergartens and 6 schools

(1 room in each), and in a car driving the same route across the city 11 times. The buildings were of different ages and construction, from the classical (brick and concrete) to modern buildings made of prefabricated parts. Integrated 24-hour samples were collected, stored in a refrigerator, and analyzed using the colorimetric method based on Schryver's reaction.

0385
Karlsson, S., Banhidi, E., Banhidi, Z.G., and Albertsson, A. (1984) "Accumulation of malodorous amines and polyamines due to clostridial putrefaction indoors", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 287-293. NTIS PB85-104206.

KEYWORD: exposure, field,source, alkylamine, architecture, odor, terpene, microorganism

Damaged malodorous self-leveling floor-coating compounds containing protein additives were analyzed by various gas chromatographic (GC) techniques; iso-butylamine, triethylamine, n-pentylamine, di-iso-butylamine, di-n-butylamine, putrescine, and B-phenylethylamine were identified. Some slow-moving amines underneath the floor-covering layer were tentatively identified. In addition, short-chain organic acids were found. Both the amines and acid groups of substances represent characteristic putrefactive fermentation products of clostridia, which researchers isolated from different caseins and building materials. The same GC patterns were obtained when analyzing spent media of pure clostridial cultures, grown on caseins medium for some months at pH levels of 10 or more. The deodorant-like smell of degradation products from plasticizers and of terpenes from wood might overlap the amine odor. A long-term accumulation of amines might represent another menace in "sick buildings".

0287
Kebbekus, Barbara, et al. (Aug. 1983) "Concentration of selected vapor and particulate phase substances in the Lincoln and Holland tunnels", J. Air Pollut. Control Assoc., 33(4):328-330.

KEYWORD: VOC, PAH, Pb, particulate, source, microenvironment, QA, vehicle, outdoor, tunnel

Lead, polyaromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) were measured in the Lincoln and Holland tunnels under the Hudson River near New York City. Sampling and analysis methods and data quality are discussed. Data tables and compound lists are provided. Pollutant concentrations were 10 to 20 times higher than those at a typical urban site.

0401
Keller, G., and Muth, H. (1985) "Radiation exposure in German dwellings, some results and a proposed formula for dose limitation", Sci. Total Environ. 45:299-306.

KEYWORD: radon,outdoor,radiation, exposure,source, foreign, home, field, thoron, Germany, statistical, architiecture

Investigations in the Federal Republic of Germany on the indoor and outdoor exposure to natural radiation from gamma rays and radon and thoron daughters are presented. The median indoor radon-222 concentration was approximately four times higher than outdoors. A correlation analysis of the data obtained showed that, indoors, the equilibrium factor is almost independent of ventilation, radon-222 concentration, and other parameters. The mean equilibrium factor was 0.3 in dwellings and approximately 0.4 outdoors. The investigations on diffusion coefficients and exhalation rates showed that the activity concentration in dwellings and in cellars can generally be explained by the radon emissions from the building materials. Only in areas of high radon concentrations was the emission from the soil a decisive factor. The mean effective dose equivalent by residence in dwellings amounted to 0.2 to 0.8 mSv/a for radon-222 daughters and approximately 0.1 mSv/a for radon-220 daughters. A relationship has been derived that permits calculation of the expected average radiation exposure in dwellings by gamma radiation and by radon inhalation as a function of the radionuclide concentration in building materials.

0632
Keller, M.D., Lanese, R.R., Mitchell, R.I., and Cote, R.W. (1979) "Respiratory illness in households using gas and electricity for cooking", Environ. Res., 19:495-503.

KEYWORD: NO2, exposure, home, health, lung, source, combustion, outdoor, demographic, appliance

A 12-month study was undertaken to determine the incidence of respiratory illlness in households in an upper-middle-class community in the Midwest. A sample of 441 families was divided into two groups, those cooking with gas and those cooking with electricity. Family health and demographic data were obtained biweekly from the participants. Ambient air was analyzed indoors and outdoors in a sample of the households, and pulmonary function tests were conducted on a subsample of the participants from both types of households. The results were compared with those from a similar study in Long Island, NY. Cooking with gas was not associated with an increase in respiratory disease or a decrease in pulmonary function.

0324
Khan, Tahir R., and Meranger, Jean C. (1983) "Recent advances in SO2, NOx and O3 personal monitoring", Environ. Int., 9:195-206.

KEYWORD: SO2, NOx, O3, personal, exposure, monitor, methodology, literature

Because the air pollution measured by stationary-monitoring stations is a poor indicator of population exposure, personal monitors are indispensible to health effects studies. This article reviews the current research on the development of personal monitors. Although most of the analytical methods reviewed appear to be sensitive to the levels of the target pollutants generally encountered in indoor and outdoor air (NO2, SO2, and O3), they lack the desired performance characteristics for a personal monitoring device, such as user safety, ease of operation, weight, and maintenance. Electrochemical transducers/sensors, which have not yet been exploited for personal monitoring, can generate real-time measurements. A few research models and commercially attractive devices that can be used in field studies are described.

0558
Kilpatrick, James S., Jr. (1986) "A criticism of Repace and Lowrey (1985)", Environ. Int., 12(1-4):29-31.

KEYWORD: exposure, smoking, methodology, dose, risk, statistical, demographic, health, literature, lung, QA, model

This letter-to-the-editor argues that in the journal's 1985 article, "A quantitative estimate of nonsmokers' lung cancer risk from passive smoking," (BLIS #86) Repace and Lowrey ignored basic statistical principles to achieve their conclusion that passive smoking causes 5,000 extra lung cancer deaths per year. Specifically, (1) their exposure estimate is based on an unrealistic worse-case scenario, (2) they arbitrarily use linear dose/response model of carcinogenesis in which passive smoking is the only cause of lung cancer in nonsmokers, and (3) they abuse unpublished and incomplete demographic data on nonsmokers' death rates. Repace and Lowrey rebut these arguments in BLIS #559.

0088
Kim, S.Y., and Kreisal, W. (Aug. 1984) "Effects of household exposure to carbon monoxide poisoning in Korea", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 117-122. NTIS PB85-104214.

KEYWORD: CO, field, foreign,health, exposure, seasonal, economic, temperature, Korea, home

The study shows that incidences of household CO poisoning cases in Korea are significantly correlated with temperature, but not with relative humidity. Examination of weather effects seemed to indicate that socioeconomic factors may also be involved.

0564
Kim, Yoon Shin, and Stock, Thomas H. (1986) "House-specific characterization of indoor and outdoor aerosols", Environ. Int., 12(1-4):75-92.

KEYWORD: trace, home, particulate, outdoor, source, ventilation, exposure, smoking, health, NO3, SO4, Pb, Zn, metal

Air was monitored simultaneously inside and outside of 12 homes in the Houston, TX, area for fine inhalable particulate matter by means of dichotomous samplers. The patterns of house-specific indoor mean concentrations, indoor/outdoor ratios, and probable sources of indoor fine aerosols are discussed, along with pertinent information on household characteristics. The results suggest that most indoor aerosols are affected by infiltration of outdoor air as well as by indoor generation, with the single most important determinant being the presence or absence of cigarette smoking. However, it is likely that the typical complexity of indoor environments makes it difficult to determine possible sources of indoor aerosol accurately.

0575
Kim, Yoon Shin, Spengler, John D., and Yanagisawa, Yukio (1986) "Measurements of indoor and personal exposures to nitrogen dioxide in Korea", Environ. Int., 12(1-4):401-406.

KEYWORD: NO2,personal,monitor,sampling,source,field, Korea, home, exposure,combustion,microenvironment,statistical,foreign

Indoor and personal exposures to NO2 were measured for 48 homes in Seoul, Korea, during January and February 1984. Passive diffusion tube samplers were placed in the kitchen and living room, and housewives wore badge-type personal samplers. The mean NO2 concentrations in kitchen and living room air were 52.6 and

43.7 nanoliter/liter (nL/L), respectively, while the mean personal NO2 exposure was 29.2 nL/L. Average personal exposure and kitchen and living room levels were higher in homes using liquified propane gas for cooking fuel than the corresponding levels in homes using natural gas. Comparing indoor measurements and personal exposure to NO2 by analysis of variance showed kitchen NO2 levels varied significantly with type of cooking fuel used, whereas living room and personal NO2 levels varied with type of heating fuel.

0139
King, Thomas A., et al. (May 1984) "Indoor air quality, environmental information handbook: combustion sources", U.S. Department of Energy, Office of Environmental Analysis, Washington, DC 20585 (217 pages). NTIS DE85-006589/LL.

KEYWORD: literature, smoking,home, source, EPA$, health, control, regulation, combustion, model

This handbook provides a comprehensive overview and reference source on the major air quality aspects of indoor combustion activities, including tobacco smoking. Quantitative and descriptive data are presented on emissions, indoor concentrations, factors influencing indoor concentrations, and health effects of combustion-generated pollutants. Models, controls, and standards applicable to combustion sources of indoor air pollution are reviewed. Potential concentrations in residential settings are estimated.

0308
Kleinman, Michael T. (1984) "Sulfur dioxide and exercise: relationships between response and absorption in the upper airways", J. Air Pollut. Control Assoc., 34(1):32-37.

KEYWORD: SO2, exposure, dose, model, health, lung, laboratory, ventilation

During exercise, higher ventilation rates and decreased time of contact with upper airway surfaces appear to result in greater doses of gases (such as SO2) being delivered to sensitive target sites within the respiratory system. In human clinical studies, the effects of SO2 on pulmonary function are indeed enhanced during exercise. A mathematical model has been developed from measurable anatomical, physiological, and physiochemical parameters as well as from controlled experiments with humans and laboratory animals. The model takes into account minute ventilation, partitioning between oral and nasal breathing, and differences in pollutant scrubbing in oral and nasal airways. The model has been tested on apparently divergent experimental results from two laboratories and resolved differences between the results of clinical SO2 exposures of resting and exercising people.

0505
Kleitman, D., Chernoff, H., Rasmussen, S., DuMouchel, W., Neuberg, D. (1981) "The relationship between indoor radon and lung cancer: a study of feasibility of an epidemiological study", U.S. EPA, Washington, DC 20460 (116 pages). NTIS PB84-192673.

KEYWORD: radon, health, lung, model, exposure,risk, epidemiology, home, field, design, smoking, statistical, economic

A study assessing the feasibility of an epidemiologic investigation of the relationship between residential radon exposure and lung cancer is described. Field measurements of residential radon levels in Maine are also described. Using these radon measurements and existing risk assessments, the authors estimate that, at most, 10% of lung cancers in Maine can be considered attributable to residential radon. The authors calculate sample sizes necessary for a case-control study of radon and lung cancer at various levels of radon and smoking health effects. The effects of misclassification of exposure variables on the probability of detecting a radon health effect are discussed. Three mathematical models (saturated logistic, simple logistic, and simple additive) are compared that could be used to estimate sample size. Costs are estimated for conducting the epidemiologic case-control study.

0388
Konopinski, Virgil J. (1984) "Residential formaldehyde and carbon dioxide", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 329-334. NTIS PB85-104206.

KEYWORD: CO2, CH2O, home, source, field, exposure, architecture, health

From 1979 through 1983, a series of investigations was undertaken to define formaldehyde concentrations in residences with and without urea-formaldehyde foam insulation (UFFI). In a limited number of situations, CO2 and relative humidity were also determined. Mean concentration of formaldehyde in UFFI residences was 0.05 ppm; and in non-UFFI residences, it was 0.09 ppm. The mean CO2 concentration was 734 ppm indoors and 208 ppm outdoors. Relative humidity indoors ranged from 31% to 78%. The most frequent health problems, reported by persons in 43.1% of the homes, were respiratory irritation, eye irritation, and headaches.

0349
Koontz, Michael D., and Nagda, Niren L. (1984) "Infiltration and air quality in well-insulated homes: 3. measurement and modeling of pollutant levels", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 511-516. NTIS PB85-104222.

KEYWORD: radon, CH2O, particulate, exposure, source,seasonal, CO, NO2, NOx, combustion, energy, weather, model, field, home

Pollutant levels in well-insulated houses are being investigated in a 2-year theoretical and experimental study involving the simultaneous measurement of meteorological variables, air exchange and circulation, and energy consumption. This paper describes concentrations of radon, radon progeny, formaldehyde, CO, and NOx observed in two houses in summer and fall 1983. Increased ventilation reduced pollutant concentrations considerably.

0481
Kosek, J.A., Giordano, J.P., and LaConti, A.B. (May 1983) "Development of SPE diffusion head instrumentation", in "Proceedings: National Symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982", pp. 333-357. NTIS PB84-148345.

KEYWORD: CO, NO, QA,personal, monitor,methodology,NO2,industrial, exposure, laboratory, EPA$

General Electric has developed a line of electrochemical sensors for monitoring such gases as CO, NO, and NO2 in mine and industrial atmospheres, using a unique solid polymer electrolyte (SPE) electrochemical cell technology. Several models of CO instruments are now in commercial production. These instruments include a direct-reading CO detector and a CO dosimeter, both of which use an air-sampling pump to bring a gas sample to the electochemical sensor cell. Use of the SPE sensor cell eliminates problems such as corrosion and containment associated with caustic or acidic electrolytes and leads to highly invariant sensor cell response and long-life operation with minimal maintenance and calibration. This instrumentation has been modified such that an air sample reaches the sensor cell by means of natural gaseous diffusion. Both the active and passive versions of these monitors can be used easily as personal dosimeters.

0102
Krasmec, J.P., and Demaray, D.E. (Aug. 1984) "Sampling and monitoring toxic gases in indoor environments", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 191-196. NTIS PB85-104214.

KEYWORD: CO, CO2, CH2O, particulate, smoking, hydrocarbon, VOC, halocarbon, sampling, methodology

Different approaches to monitoring indoor air pollutants are described briefly. Indoor sampler design criteria are outlined. Grab samplers, personal samplers, passive and single-use devices, and in-situ measurement instruments are compared to novel, syringe/adsorbent tube samplers. These instruments provide an automated, sequential, time-averaged collection of a variety of indoor air pollutants, including hydrocarbon/halocarbon organic vapors, CO, CO2, formaldehyde, tobacco smoke, combustion and odorous mixtures, and particulate matter. In addition, the samplers can be used in indoor infiltration studies. The design and operation of the new samplers are detailed. Current and potential applications are also discussed.

0777
Krause, C., and Englert, N. (1980) "Health evaluation of PCP (pentachlorophenol) containing wood preservatives in rooms", Holz als Roh- Werkstoff, 38:429-432.

KEYWORD: PCP, wood, home, biomonitoring, laboratory, exposure, foreign, Germany, pesticide

The actual exposure to PCP after application of wood preservatives was determined by analyzing indoor air samples in 104 homes and the urine from more than 1,000 persons with varying PCP exposure. In 250 persons with elevated PCP exposure, additional general medical examinations and laboratory diagnoses were performed. A clear relation between elevated urine PCP concentrations and deviations from "normal" could not be derived from the findings.

0188
Kreiss, K., Gonzalez, M.G., Conright, K.L., and Scheere, A.R. (1982) "Respiratory irritation due to carpet shampoo: two outbreaks", Environ. Int., 8:337-341.

KEYWORD: SO4, health, lung, office, school, architecture

Dried detergent residue left in carpets after they were shampooed with underdiluted carpet shampoo caused respiratory irritation among most employees in an office building and among all staff members and most children in a day-care center. Symptoms included cough, dry throat, difficulty in breathing, nasal congestion, and headache. Eye irritation was also noted by day-care center staff members. Symptoms persisted for many weeks until the carpets were steam cleaned twice. The major ingredient of the three shampoo products implicated in these two outbreaks and in a third similar report is sodium dodecyl sulfate, a respiratory irritant in mice. Unpublished occupational investigations suggest that exposure to soap dust may be associated with pulmonary function abnormalities in some exposed workers. Detergent dust is a newly recognized example of an indoor air pollutant and should be considered when patients or employees complain of respiratory or eye irritation.

0498
Kring, E.V., Ansul, G.R., Basilil, A.N., McGibney, P.D., Stephens, J.S., and O'Dell, H.L. (1984) "Sampling for formaldehyde in workplace and ambient air environments -- additional laboratory validation and field verification of a passive air monitoring device compared with conventional sampling methods", Am. Ind. Hyg. Assoc. J., 45(5):318-324.

KEYWORD: CH2O, field, home, monitor,personal,exposure,industrial, methodology, QA, laboratory

Results of three extensive tests in industrial plants using both area and personal sampling and involving 51 sets of comparison samples show the Du Pont Pro-Tek Formaldehyde Badge to have excellent correlation with three commonly used formaldehyde-monitoring methods. Field tests in mobile homes gave similar results. In addition, comprehensive laboratory validation tests reportedly confirm an overall accuracy of +/- 9.6% to +/- 11.6% for the badge over an exposure range of 0.12 to 6.8 ppm. Laboratory test data show that the badge (1) meets Federal accuracy requirements of less than +/- 25% down to 1.6-ppm hours (200 ppb) for an 8-hour exposure; (2) is capable of accurately sampling for 15-minute exposures; and (3) is not affected by air pressure or variations in relative humidity.

0345
Kulmala, V., Salminen, A., Graeffe, G., Janka, K., Keskinen, J., and Rajala M. (1984) "Long-term monitoring of indoor air quality and controlled ventilation in public buildings", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 435-441. NTIS PB85-104222.

KEYWORD: radon, aerosol, CO2,ventilation, office, field, foreign, Finland, energy

Long-term monitoring of radon, aerosol, and CO2 was carried out in two public buildings in Finland. In each case, a distinct periodic behavior of pollutant concentrations was observed. CO2 and aerosol showed maximum levels during working hours, but fluctuations of the aerosol concentration were faster and more irregular. Radon peaked at night and on weekends, dropping off rapidly on work day mornings when ventilation was turned on. Reasons for the fluctuations are discussed briefly in terms of indoor sources and periodic ventilation. A case study of CO2-controlled ventilation was conducted in one of the buildings. The estimated daily energy savings were between 13 and 20%, and no significant changes in the pollutant concentrations could be observed.

0457
Kusuda, T., Silberstein, S., and McNall, P.E., Jr. (1980) "Modeling of radon and its daughter concentrations in ventilated spaces", J. Air Pollut. Control Assoc., 30(11):1201-1207.

KEYWORD: radon, ventilation, model, radiation, exposure, home, architecture

To predict indoor radiation levels caused by radon daughters at low building ventilation and air leakage rates, researchers used differential equations that governed the decay and venting of radon 222 and its daughters. A computer program based on the equations was written to predict radon and radon daughter concentrations, total potential alpha energy concentration, and the equilibrium factor. The program can be, and is readily, used by building designers. Sample calculations using the program showed that potential alpha energy levels in a tightened building can commonly reach about 0.01 working level, an amount more than twice as high as concentrations currently found in most houses.

0306
Lamb, B., Westberg, H., Bryant, P., Dean, J., and Mullins, S. (1985) "Air infiltration rates in pre- and post-weatherized houses", J. Air Pollut. Control Assoc., 35(5):545-551.

KEYWORD: hydrocarbon, radon, outdoor, ventilation, energy, field, CH2O

Air filtration rates were measured via a tracer dilution method in 10 eastern Washington houses before and after the houses were weatherized in order to determine the effectiveness of weatherization procedures. Infiltration rates during typical meteorological conditions ranged from 0.3 to 1.0 air exchanges per hour (ex/h) among the houses. Reduction in these infiltration rates due to weatherization also varied considerably from "essentially no change" to "40% reduction in the air exchange rate". The average reduction was approximately 16%. Infiltration rates were measured continuously in one house during several weeks, and the results showed that the extended use of doors can cause infiltration rates to increase from less than 1 ex/h for a closed house to more than 3 ex/h. Limited air pollution measurements conducted during the study indicated that formaldehyde and radon concentrations were quite low indoors, while individual indoor hydrocarbon concentrations were much higher than those measured outdoors.

0343
Lambert, W.E., and Colome, S.D. (1984) "Effect of reduced building ventilation rates on occupant exposure and response to carbon monoxide", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 277-285. NTIS PB85-104222.

KEYWORD: exposure, ventilation, energy, outdoor, biomonitoring, model, CO2

In weatherization of buildings to minimize convective heat loss, the air exchange rate is reduced. Thus indoor pollutants are retained near the occupants. Further, outdoor pollutants may be concentrated indoors under particular peak and duration conditions. The health significance of this latter occurrence was evaluated with a generalized indoor-outdoor model for a conservative pollutant. Protection against transient outdoor peaks varied with exchange rate, ambient peak height, duration, and periodicity. Under conditions approaching steady state, indoor fluctuation is dampened, and geometric mean concentrations increase as exchange rates are reduced. Using a predictive equation for carboxyhemoglobin formation, a reference individual's response to indoor versus ambient profiles was calculated. The traditional assumption that reduced ventilation rates protect against outdoor peaks was evaluated in the context of a generally reduced variance about the mean in indoor profiles.

0389
Lamm, S.H. (1984) "Upper respiratory irritation symptoms and formaldehyde exposure levels among mobile home residents", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 361-366.

NTIS PB85-104206.

KEYWORD: CH2O, health, home, exposure, statistical, field, lung

Residents of mobile homes in Minnesota, Wisconsin, and Washington complaining of "formaldehyde" problems in their homes participated in health studies conducted by State personnel. Formaldehyde (CH2O) levels in the homes were determined using impactor collection tubes and the chemical analysis method approved by the National Institute for Occupational Safety and Health. The residents completed questionnaires detailing their symptoms. Residents were classified by the level of CH2O detected in their homes (grouped in 0.5-ppm intervals). For each symptom, the proportion of residents in each exposure group reporting that symptom was calculated. Symptoms did not increase with CH2O levels less than 2 ppm, with the possible exception of an increased prevalence of eye complaints in the Minnesota study. Symptom prevalences at exposures greater than 1.5 ppm were generally no different from prevalences at 0.0 to 0.5 ppm. Further, exposure levels in the study homes did not differ from those in randomly chosen mobile homes, after adjusting the data for age of home, according to a Wisconsin study.

0396
Lampos-Venuti, G., Risica, S., Antonini, A., Bobbi, G., and Leogrande, M.P. (1985) "Radon and radon daughter evaluation in a natural radioactivity survey indoors", Sci. Total Environ., 45:373-380.

KEYWORD: radon, outdoor, methodology, radiation,source, exposure, foreign, Italy

A survey estimating indoor exposures in five towns in Italy is presented. Gamma spectrometry of building materials, exposure rate measurements indoors and outdoors, and radon concentration measurements indoors were taken with different techniques. Mean gamma exposure rate and mean radon concentration were correlated in the houses investigated. Mean effective dose equivalents for the inhabitants of the five towns are reported.

0301
Landa, Edward R. (1984) "Radon in earth-sheltered structures", Underground Space, 8:264-269.

KEYWORD: radon, architecture, home, exposure, energy, monitoring

Radon concentration in the indoor air of six residential and three nonresidential earth-sheltered buildings in eastern Colorado was monitored quarterly over a 9-month period using passive, integrating detectors. Average radon concentrations during the three 3-month sampling periods ranged from about 1 to 9 picoCuries/liter (pCi/L)--although one building, a poorly ventilated storage bunker, had concentrations as high as 39 pCi/L. These radon concentrations are somewhat greater than those typically reported for conventional buildings (about 1 pCi/L); but they are of the same order of magnitude as radon concentrations reported for energy-efficient buildings that are not earth sheltered.

0476
Lautenberger, W.J., Kring, E.V., and Morello, J.A. (1981) "Theory of passive monitors", Ann. Am. Conf. Gov. Ind. Hyg., 1:91-99.

KEYWORD: sampling, exposure, monitor, personal, literature, VOC, methodology, temperature, humidity, QA

Recently, interest has been growing in using a passive monitor, rather than a pump/impinger or pump/solid-sorbent tube, to sample organic and inorganic vapors. In general, passive monitors depend on permeation- and/or diffusion-controlled mass transport sampling mechanisms. With the pump/tube method, the mass of the vapor collected is a direct function of the sampling rate of the pump (cm3/min), ambient concentration (mg/m3), and sampling time (min). When permeation-controlled passive monitors are used for sampling, the mass uptake of the monitor is controlled by the physiochemical characteristics of the membrane and the contaminant. A theoretical discussion of the effects of air movement, temperature, pressure, relative humidity, coadsorption or coabsorption of other contaminants, and the amount and type of adsorbent or absorbent is reviewed, and the relevancy to the practicing industrial hygienist is discussed. The effects of relative humidity and temperature, as well as the overall sampling range of the device, must be considered if the devices are to be used properly in the field.

0456
Leach, J.F., Robinson, G.R., and Sandalls, F.J. (1982) "Aircraft cabin air ozone contamination and compliance with regulations", Atmos. Environ., 16(5):1021-1026.

KEYWORD: statistical, methodology, vehicle, regulation, aircraft, distribution, O3

Fifteen O3 measurements were taken of the cabin air in the "Concorde" aircraft. These measurements were ranked in order and plotted as log-normal and extreme value cumulative probability distributions. Results showed that the log-normal distribution gave adequate accuracy for regulatory purposes, and one-side tolerance limits may be used for statistical methods of compliance with any regulatory limit. Similarly, researchers found that regulatory compliance achieved by O3 destruction ratio may be difficult because of the extreme stratification of O3 in the lower stratosphere.

0650
Leaderer, B.P., Cain, W.S., Isserhoff, R., and Berglund, L.G. (1981) "Tobacco smoke in occupied spaces: ventilation requirements", Paper no. 81-22.6, presented at the 74th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (14 pages).

KEYWORD: smoking, ventilation, exposure, control, CO, model, laboratory, monitor, control, smoking, particulate

Two sets of experiments in an aluminum-lined chamber explored steady-state concentrations of CO and total suspended particulates (TSP), their relation to rate of smoking and ventilation, and their removal by adsorption to surfaces. First, CO and TSP were monitored with four smokers and three smokers in the chamber. The nonsmoker's psychophysical reactions to tobacco smoke odor also were recorded. Second, steady-state concentrations of CO and TSP from four smokers were monitored during fresh-air ventilation and during fan mixing without fresh air. Smoking rates were controlled in both sets of experiments. Ventilation rate alone governs removal rate of CO. Both ventilation and surface adsorption govern the TSP removal rate. Ventilation rates that reduce CO concentrations to acceptable levels do not do so for TSP. Under steady-state conditions, and subject to other limitations, CO may serve moderately well as a proxy for TSP.

0479
Leaderer, B.P., Cain, W.S., Isserhoff, R., and Berglund, L.G. (1984) "Ventilation requirements in buildings--II. particulate matter and carbon monoxide from cigarette smoking", Atmos. Environ., 18(1):99-106.

KEYWORD: ventilation, CO, particulate, smoking, energy, health, control, laboratory

Current efforts to reduce ventilation rates in buildings may conserve energy but may, in turn, impair human health and welfare through increased levels of indoor contaminants. Tobacco combustion is one important source of indoor pollution. Measurements were made in an aluminum-lined environmental test chamber of both steady-state levels and decays of total suspended particulate (TSP) mass between 0.01 and 10 um. CO generated during various rates of cigarette smoking and at various rates of ventilation was measured also. Of the particulate mass, 98% fell between 0.05 and 1.0 um, with a volume median diameter of 0.225 um. For many combinations of smoking rate and ventilation rate, including ventilation rates above normal, TSP exceeded levels considered acceptable outdoors. This rarely occurred, however, with CO. Although ventilation above governed removal of CO from the chamber, adsorption on surfaces (e.g., ductwork, walls) provided an additional mechanism for removing TSP. Even with the additional clearance offered by adsorption, particulate levels will exceed commonly accepted background levels unless ventilation during smoking equals about 35 cfm per occupant. An electrostatic precipitator, on the other hand, will very quickly drive TSP levels down to very low values. This study found that the latest ASHRAE ventilation standard appears to be adequate to maintain CO levels resulting from cigarette smoking at acceptable levels and that ventilation alone will control the removal of CO.

0097
Leaderer, B.P., Zangraniski, R.T., Berwick, M., Stolwijk, J.A.J., and Qing-Shan, M. (Aug. 1984) "Residential exposure to NO2, SO2 and HCHO associated with unvented kerosene space heaters, gas appliances, and sidestream tobacco smoke", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 151-156. NTIS PB85-104214.

KEYWORD: NO2, SO2, CH2O, source, combustion, home, exposure, smoking, appliance

Integrated levels of NO2, SO2, and formaldehyde were sampled during six 2-week periods during the heating season of January-April 1983 in 303 homes in the New Haven, CT, area. Indoor-to-outdoor NO2 ratios were 0.577 +/- 0.305 for homes with no known source of NO2. Average levels of NO2 were comparable for homes with either a kerosene heater or a gas stove. Homes with both a kerosene heater and a gas stove had average NO2 concentrations approximately double those with only one source. Residences with smokers had higher NO2 levels than those without. In residences with kerosene space heaters, SO2 concentrations corresponded to the sulfur content of the fuel. Levels of NO2 and SO2 during kerosene heater use were estimated as four to five times higher than the average values measured during the 2-week sampling period. Formaldehyde levels were low and not associated with indoor combustion.

0776
Lebowitz, M.D., Holberg, C.J., and Dodge, R.R. (1983) "Respiratory effects on populations from low-level exposure to

ozone", Paper no. 83-12.5, presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (8 pages).

KEYWORD: exposure,O3,health,field,lung,particulate, monitor, NOx, CO, statistical, temperature, outdoor, weather, appliance

The study attempted to evaluate the respiratory effects of O3, independently and interdependently of other pollutants and meteorological phenomena, both indoors and outdoors. In Tucson, AZ, 229 subjects (117 families) were monitored over a 2-year period using daily symptom diaries and mini-Wright peak flow monitors. All families provided environmental information on their houses. Air pollutants and microbiological constituents were monitored indoors and outdoors: total suspended particulates (TSP) by Gelman filters and Thomas pump, O3 by a Daisibi monitor (UV photometer), CO by grab sampling and a Bendix CO IR analyzer, NOx (unsuccessfully) by a Bendix chemiluminescent analyzer. TSP indoors ranged from 5.7 to 68.5 ug/3. Simultaneous micro-outdoor TSP ranged from 2.1 to 169.6 ug/m3. The interaction between O3 and TSP in relation to peak flows was statistically significant. O3 and temperature correlated with prevalence rates of acute "asthma" symptoms in asthmatics, but O3 had no independent effect within any temperature range. O3 had no effect on prevalence rates of rhinitis in conjunction with stove usage, but its effect was seen only in those with gas stoves.

0781
Lebowitz, Michael D. (1983) "Health effects of indoor pollutants", Ann. Rev. Public Health, 4:203-221.

KEYWORD: multimedia,multipollutant,exposure, literature, control, activity, regulation, source, health, dose, outdoor

This overview of indoor pollution dicusses pollutants, sources, concentrations, health effects, control mechanisms, regulation issues, and research methods. Special attention is given to CO, particulates, volatile organic compounds, NO2, formaldehyde, radon, asbestos, various fibers, CO2, and microorganisms. A table identifies sources and common concentration ranges. Research to estimate total human exposure to pollutants from generic activities in varied locations is discussed. While the individual may be responsible for limiting exposures, public health agencies can help by addressing consumer product liability and building code standards, and by supporting research on control mechanisms and epidemiological factors.

0312
Lebowitz, M.D., Corman, C., O'Rourke, M.K., and Holberg, C.J. (1984) "Indoor/outdoor air pollution, allergen and meteorological monitoring in an arid southwest area", J. Air Pollut. Control Assoc., 34(10):1035-1038.

KEYWORD: O3, CO, particulate, allergen, source, outdoor, NO2, smoking, weather, activity, appliance

Sources and concentrations of indoor air pollutants and aeroallergens were evaluated in arid Tucson, AZ. One major purpose was to appraise the interaction of indoor and outdoor human exposures. A rough time budget study showed that 74% of adults spent 75% or more of their time in some indoor environment. Outdoor and indoor concentrations of total suspended particulates (TSP), respirable suspended particulates (RSP), CO, O3, and aeroallergens were measured for 41 detached dwellings. Mesoenvironmental monitoring was conducted for TSP, CO, NO2, O3, and aeroallergens; ambient TSP frequently exceeded National Ambient Air Quality Standards (NAAQS), as did both CO and O3 on occasion. Indoor TSP and RSP were lower than outdoor levels and of a different composition. Outdoor infiltration fell rapidly for particles and pollen as distance indoors increased. CO was low indoors, and O3 was very low. TSP and RSP correlated significantly with tobacco smoking, and CO correlated with gas stove use. Temperature varied minimally indoors, and relative humidity indoors was similar to outdoor readings in this climate. Researchers concluded that better particle characterization and better estimates of total exposure are required.

0766
Lebowitz, M.D., Holberg, C.J., O'Rourke, C.G., and Dodge, R. (1983) "Gas stove usage, CO and TSP, and respiratory effects", Paper no. 83-9.1, presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (12 pages). NTIS PB83-250357.

KEYWORD: smoking,combustion, source, health, personal,CO, NO2,O3, particulate,monitoring,field,outdoor,weather,EPA$,appliance

This paper examines the daily peak flows of pollutants in homes of asthmatic and nonasthmtic families and exposure to gas stove emissions and passive smoking. The indoor air of 117 families (229 subjects) in Tucson, AZ was investigated for a 2 years using daily diaries and peak flow meters. In a random cluster sample of representative households, temperature, humidity, and air pollutants were measured and samples taken for O3, CO, NO2, and total suspended particulates. Correlations are presented, for relationships between the measured parameters, source usage and residents' medical symptoms.

0760
Lebowitz, Michael D. (1976) "Aerosol usage and respiratory symptoms", Arch. Environ. Health, 58:83-86.

KEYWORD: lung, health, demographic, smoking, source, statistical, indoor, epidemiology, exposure, design

In an epidemiological study of 3,485 selected individuals in Tucson, AZ, aerosol usage appears to correlate with respiratory symptoms. This effect persists after adjusting for correlations of age, smoking and the prevalence rates for symptoms; and appears to exist for specific types of aerosols. Further specification and clarification of these relationships are needed in the epidemiological study. Critical evaluation in vitro and in vivo models is also crucial. The propellants and active ingredients must be studied toxicologically to determine the mechanism and extent of specific actions on organisms.

0647
Lebowitz, Michael D. (1983) "Utilization of data from human population studies for setting air quality standards: evaluation of important issues", Environ. Health Perspect., 52:193-205.

KEYWORD: QA, epidemiology, regulation, distribution, methodology, exposure, health, multipollutant, risk, statistical, NAAQS

Epidemiological studies are highly relevant to the process of setting National Ambient Air Quality Standards because the standards are intended to protect people from adverse health effects. However, the use of data derived from these studies for setting standards is problematic because of the difficulties of gathering data of adequate quality. This paper addresses appropriate exposure measurement and health assessment methods, and the problems of multiplex variables and colinearity, which are critical in assessment of exposure-effect relationships. A major question in the use of epidemiological data for setting standards is not necessarily scientific reliability or validity, but arises from attempting to translate adequate science into policy decisions.

0674
Lebowitz, Michael D. (1983) "Passive smoking", in "Energy, air pollution and health: fact sheets", American Lung Association, 1740 Broadway, New York, NY 10019-4374, pp. 22-24.

KEYWORD: microenvironment, exposure,health, CO,lung, VOC,smoking, particulate, control, ventilation, risk, activity, architecture

This fact sheet outlines the hazard of passive (side-stream, second hand) cigarette smoke. It covers the primary microenvironments, pollutants associated with passive smoke, physical dynamics such as ventilation and architecture contributing to human exposure, the history of research on health effects (with special attention on studies of children), and methods for controlling human exposure.

0724
Lebowitz, Michael D. (1984) "The potential of lung cancer from passive smoking", Berglund, B., Lindvall, T., and Sundell, J. Eds., "Indoor air, vol. 1, recent advances in the health sciences and technology", Swedish Council for Building Research, Stockholm, pp. 59-70. NTIS PB85-104180.

KEYWORD: research, health, methodology, epidemiology, literature, smoking, ventilation, lung, demographic, exposure, home, office

This article reviews the evidence for and against the hypothesis that passive smoking causes lung cancer. Passive smoke constituents have caused cancer in laboratory animals, but at exposures much larger than concentrations found in buildings. Epidemiologic studies using indirect and qualitative estimates of exposure have not been conclusive. Future research into this issue must use more reliable measures of exposure and consistant methodology.

0755
Lebowitz, Michael D. (1984) "Influence of passive smoking on pulmonary function: a survey", Prev. Med., 12:645-655.

KEYWORD: smoking, health, lung, microorganism, demographic, dose, methodology, literature, children

Effects of passive smoking on pulmonary function are reviewed. A great deal of confusion and controversy still exist in children -- the range of the many effects studied is limited, and most prospective studies show small effects. However, respiratory infections in children may increase with passive smoking. Pulmonary function decreases by 0 to 3% from conception to 20 years, small differences in absolute magnitude. In healthy adults, the effects on pulmonary function and symptoms are not of concern; asthmatics, however, require further study. A prospective study of airway-obstructing diseases in Tucson, AZ, concluded that the effect of passive smoking on pulmonary function or respiratory symptoms (recorded on a daily basis) in children is not positive. Passive-smoking children show responses to other irritants. In adults, no effect was seen, even in those with asthma or airway-obstructive diseases; this may be due to low dosage. Further, more appropriate studies are needed to understand the role of passive smoking on pulmonary function.

0553
Lebowitz, Michael D. (1986) "The potential association of lung cancer with passive smoking", Environ. Int., 12(1-4):3-9.

KEYWORD: health, risk, exposure, lung, smoking, model, dose, literature, epidemiology

The potential association of lung cancer with passive smoking has been studied epidemiologically, clinically, and mathematically. There have been both positive and negative studies, such that the association is still considered a potential rather than probable one. These studies, and the mathematical models, indicate that the major factor in determining the relationship is the dose, and that more research is required to determine the dose side of the dose-response relationship.

0186
Lebowitz, Michael D., et al. (1982) "The adverse health effects of biological aerosols, other aerosols, and indoor microclimate on asthmatics and nonasthmatics", Environ. Int., 8:375-380.

KEYWORD: particulate,lung,outdoor,source,effect,passive, smoking, health, demographic, statistical, aerosol, activity, appliance

Asthmatic and nonasthmatic families in a representative community population sample were monitored over a 2-year period using daily diaries. Simultaneous micro-indoor and outdoor monitoring was conducted in a representative sample of houses for air pollutants, pollen, fungi, algae, and climate. The relationship of indoor to outdoor factors can be demonstrated. Acute symptoms were strongly related to age, weakly related to sex, and not related to smoking habits. Suspended particulate matter and pollen were related to symptoms in asthmatics and nonasthmatics. Fungi might be related to symptoms as well. The use of gas stoves is qualitatively related to symptoms. Algae and other contaminants of evaporative coolers do not appear to be important in producing symptoms. More complex statistical analyses are required to determine interactions of these factors. Distinction has to be drawn between infectious episodes, allergic episodes, nonallergic but similar episodes, and asthmatic attacks. This study demonstrates the need for further investigations in this area.

0539

Lebowitz, Michael W. (1981) "Discussion of toxic air pollutant health effects", Am. Rev. Respir. Dis., 124:521-522.

KEYWORD: risk, benzene, dose, model, literature, CH2O, health, epidemiology, statistical, methodology, exposure, regulation

Demonstrated toxicity must be a major criterion for classification of a pollutant as a toxic substance. Assessment of the health hazards and attendant risks of exposure to such pollutants is also essential. Some major questions must be answered. What type of toxicity data are best suited for this purpose? How are the criteria for toxicity determined and by whom? What confidence can be ascribed to such results, especially to allow extrapolation to low doses? If a dose-response cannot be demonstrated, can confidence be given to estimates of effects in the real world? What type of evidence, of biological plausibility, or consistency (if not causality), is necessary? These question, which must be answered to avoid epidemiological fallacies, continue to plague those charged with reviewing the evidence, even before consideration of regulations. The regulatory histories of benzene and formaldehyde illustrate these points.

0307

Lebowitz, M.D., Holberg, C.J., Boyer, B., and Hayes, C. (1985) "Respiratory symptoms, and peak flow associated with indoor and outdoor air pollutants in the southwest", J. Air Pollut. Control Assoc., 35(11):1154-1158.

KEYWORD: O3, NO2, particulate, outdoor,health, home, CO, smoking, source, appliance

A symptom-stratified, geographic cluster sample of 117 middle-class households was studied. Daily diaries of symptoms and peak flows were obtained for 211 subjects during a 2-year period. O3, total suspended particulates (TSP), respirable suspended particulates (RSP), CO, temperature, and relative humidity were determined indoors in a sample of homes. Questionnaires determined type of stove and number of smokers in all households. Ambient pollutants (O3, TSP, CO, NO2) were monitored in or near the clusters, as were temperature and relative humidity. Smoking in the household was significantly correlated with TSP and RSP. Indoor CO was significantly correlated with gas stove use. Normal adults under age 25 had daily peak flows (PEF) associated with outdoor O3 (after adjusting for other factors). Asthmatics' PEF was associated with smoking, gas stove use, and outdoor NO2, and with outdoor O3 and temperature, after adjusting for other factors. Indoor and outdoor factors affected asthmatic symptoms, after controlling for age, sex, smoking, and other ambient environmental variables.

0182
Lebowitz, Michael D. (1983) "The effects of pressurized aerosols on respiratory symptoms and physiology", Sci. Total Environ., 29:19-27.

KEYWORD: aerosol, home, smoking, lung, health, response, dose, source, statistical

In a general population sample, use of pressurized aerosols appears to be associated with transient symptoms, but it does not appear to lead to chronic respiratory complaints or functional abnormalities. This is true in both atopic and nonatopic subjects. Furthermore, changing patterns of aerosol use are not associated with changes in respiratory symptoms. Thus, household and cosmetic aerosols do not appear to be important risk factors for respiratory diseases.

0761
Lebowitz, Michael D., and Burrows, Benjamin (1976) "Respiratory symptoms related to smoking habits of family adults", CHEST, 69:48-50.

KEYWORD: statistical, smoking, activity, demographic, research, health, exposure, lung, children

In a study of the effects of family smoking habits on the symptoms of other family members, self administered questionnaires showed that symptoms, especially of children, are related to smoking habits. However, these results were not significant when adjusted for correlations with adult symptoms. Longitudinal studies of the children are needed to determine long-term effects.

0185
Lebowitz, Michael D., Armet, David B., and Knudson, Ronald (1982) "The effect of passive smoking on pulmonary function in children", Environ. Int., 8:371-373.

KEYWORD: smoking, children, health, lung

A study of ventilatory function was conducted in 344 families in a representative community sample in Tucson, AZ. Aggregate household pulmonary function, which is proportional to aggregate household body mass, might affect the relationship of children's pulmonary function to parental smoking. When household aggregation of body mass was taken into account, there was no relationship of children's pulmonary function values to parental smoking. Passive smoking due to parental smoking does not seriously affect permanent markers of respiratory disease such as pulmonary function.

0100
Lebret, E., Van de Weil, H.J., Noij, D., and Boleij, J.S.M. (1986) "Volatile hydrocarbons in Dutch homes", Environ. Int., 12(1-4):323-332.

KEYWORD: VOC, field, exposure, smoking, model, source, outdoor, foreign, Netherlands

Weekly average concentrations of 45 volatile hydrocarbons were determined in 134 houses in Ede, The Netherlands. The same volatile hydrocarbons were measured in four houses every second week for half a year. Virtually all hydrocarbons had higher indoor than outdoor concentrations. Clustering of several of the solvent-type components indicated the existence of common sources. Higher concentrations of total volatile hydrocarbons were found in houses with smokers compared to houses with nonsmokers. Repeated measurements showed stable indoor levels for some components in some houses, but rather large variations for other components and other houses. The results suggest that modeling of indoor levels on the basis of emission rates of building materials alone has serious drawbacks.

0664
Lefcoe, Neville M., and Inculet, Ion I. (Feb. 1971) "Particulates in domestic premises: I. ambient levels and central air filtration", Arch. Environ. Health, 22:230-238.

KEYWORD: particulate, control,exposure, home, field, ventilation, smoking, health, activity

Particulates were sampled in the ventilation return air of a home with central ventilation and an electrostatic precipitator in the main duct. The average counts in the 0.3-, 0.5-, and 1.0-micron ranges were related to the normal activities: children playing, house cleaning, and smoking. Counts in all ranges under minimal activity were significantly lower when the filter was on compared to when the filter was off. Cleaning and dusting inside overwhelmed the filter. Smoking one cigar raised particle counts by a factor of 100. These concentrations returned to normal in 3 hours with the filter off and 1 or 2 hours with it on.

0566
Lehtimaki, M., and Graeffe, G. (1986) "Measurement of air ions", Environ. Int., 12(1-4):109-113.

KEYWORD: methodology, QA, radon, particulate, laboratory, ion, foreign, Finland

A modified method has been developed for simultaneously measuring of positive and negative ions. A single aspiration condenser has been used in constructing a compact instrument for studying the behavior of small ions in indoor air. The principle of the ion-measuring technique is discussed. Construction of the ion meter, possible problems of ion measurements, and examples of results are included.

0251
Leidy, R.B., et al. (1982) "Concentration and movement of diazinon in air." J. Environ. Sci. Health Pestic. Food Contam. Agric. Wastes, B17(4):311-319.

KEYWORD: diazinon, pesticide, personal, home, exposure, risk

Airborne concentrations of diazinon were measured in rooms for 21 days after it was applied to cracks and crevices. Treated rooms had residues of 38 mg/m3, adjacent rooms 1 mg/m3. Low levels of diazinon were detected in all rooms 21 days after application; small amounts of residues were found on respirator pads and waist pads worn by the applicator. Data indicated no serious hazard to an individual from the prescribed diazinon application rate.

0293
Leidy, R.B., Wright, C.G., Dupree, H.E., and MacLeod, K.E. (1984) "Concentration and movement of diazinon in air, II, vertical distribution in rooms", J. Environ. Sci. Health Pestic. Food Contam. Agric. Wastes, 19(8-9):747-757.

KEYWORD: diazinon, ventilation, pesticide, sampling

The vertical distribution of diazinon in air was measured for 35 days after it was applied to cracks and crevices in a dormitory. Residue levels were higher at floor level than at chest and ceiling heights on the first day, but tended to equalize by 7 days. Residues in adjacent, upper, and lower rooms were equivalent at all sampling positions. Low, but measurable, residues were detected in air samples 35 days after application, indicating that low levels of the insecticide will remain for several weeks in structures protected from direct sunlight and ventilation.

0362
Letz, R., Quackenboss, J.J., and Spengler, J.D. (1984) "Effects of choice of exposure index in NO2 epidemiological studies", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 261-266. NTIS PB85-104198.

KEYWORD: exposure, home, source, health, statistical, literature, NO2, lung, children

Analyses of respiratory symptom and pulmonary function data demonstrate the importance of direct NO2 measurements rather than categorical variables such as cooking fuel as the exposure index. Use of NO2 measurements from a child's home to estimate exposure prevents misclassification and reduces exposure uncertainty present when a categorical variable is used. No statistically significant relationship was found between NO2 concentrations measured in children's homes and either their lung functions or the prevalence of respiratory symptoms. However, when personal monitor data were used as the exposure index, the estimated effects were consistent with potential exposure-response relationships.

0571
Levin, H., and Hahn, J. (1986) "Pentachlorophenol in indoor air: methods to reduce airborne concentrations", Environ. Int., 12(1-4):333-341.

KEYWORD: PCP,health,regulation,research,exposure,literature,food, office, biomonitoring, control, pesticide, wood, ventilation

Pentachlorophenol (PCP) is widely used in buildings as a wood preservative and as a fungicide in finished materials. The general population is routinely exposed to trace concentrations. PCP has been found in low concentrations in food, indoor air, many consumer items, and on the surfaces of playground furnishings and other outdoor wood. Human health effects have not been observed in occupants of buildings with low PCP air concentrations. Increased body burdens have been found in occupants of homes where PCP air concentrations were 0.2 to 0.4 ug/m3 and in office workers where concentrations were 7 to 10 ug/m3. Such incidences and the severe toxicity of some commercial PCP contaminants have resulted in efforts to limit population exposures to indoor PCP. In a large office building, PCP-treated timbers were sealed, reducing PCP air concentrations from 27 to 5.9 ug/m3. Improved ventilation further reduced air concentrations to 3.2 ug/m3. Body burdens were increased in a sample of the building's occupants. Recently, the integrity of the sealant appeared to have been destroyed, and cracks in the beams have appeared. Further research is necessary to determine how long applied sealants last and to establish acceptable limits for indoor PCP concentrations.

0625
Levine, M.S., Corn, M., Billings, C., Gelletley, S. Singh, J., and Blake, C.L. (1981) "An investigation of health concerns in a large office building", Draft of paper presented at the International Symposium on the Indoor Environment at Amherst, MA, October 13-17, 1981 (14 pages).

KEYWORD: CH2O, office, humidity, microorganism, field, NO2, CO, ventilation, particulate, exposure, hydrocarbon

Reports by office building occupants of poor indoor air quality due to high humidity, mold, and poor ventilation were confirmed by industrial hygiene measurements. Excessive quantities of CO, formaldehyde, particulate matter, NO2, and hydrocarbons were not found, and reports of specific symptoms could not be attributed to specific toxic exposures. However, such relationships may exist in certain instances. The distribution of health complaints reported by the occupants and their attribution to the work situation did not differ from the distribution of health complaints received from a comparable building. Thus no specific symptom or symptom complex was identified as being uniquely present in the building of interest. However, the greater number of complaints received from occupants of the building may indicate existing health problems have been worsened by the confirmed air quality problems.

0079
Lewis, R.G., Bond, A.E., and Fitz-Simons, T.R. (June 1986) "Monitoring for non-occupational exposure to pesticides in indoor and personal respiratory air", Paper no. 86-37.4, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (15 pages).

KEYWORD: pesticide, outdoor, water, personal, exposure, monitor, NOPES, source, dermal, methodology, home, TEAM

The primary objective of this study was to determine the reliability of the proposed methodology and to obtain an estimate of the frequency distribution of nonoccupational exposure to home and garden pesticides through air, dermal, drinking water, and dietary routes. Secondary objectives were to obtain an estimate of the relative importance of each route to total exposure and to identify probable sources of the pesticides. A pilot investigation was carried out using nine homes in Jacksonville, FL, during August 1985. Fixed-position, indoor, and personal exposure monitoring were performed at each dwelling. More than 20 of the target chemicals were detected in indoor air at levels from less than 10 ng/m3 to as high as 15 ug/m3.

0711
Lewis, R.G., Martin, B.E., Sgontz, D.L., and Howes, J.E. (1985) "Measurement of fugitive atmospheric emissions of polychlorinated biphenyls from hazardous waste landfills", Environ. Sci. Technol., 19(10):986-991.

KEYWORD: PCB, field, monitor, industrial, sample, landfill

Four landfills containing large quantities of polychlorinated biphenyls (PCBs) were monitored for atmospheric emissions. Three were uncontrolled and contained large numbers of electrical capacitors, many scattered on the surface and leaking PCB fluids. The other is a state-of-the-art PCB waste landfill designed to exceed requirements of the Toxic Substances Control Act of 1978 (TSCA). Both high-volume and low-volume air sampling equipment was used at each landfill to monitor PCBs upwind and downwind. In addition, vents into the wastes were monitored at the TSCA landfill. Samples were collected simultaneously at two locations for quality assurance purposes and to obtain information on sampling performance and comparability. Atmospheric PCB concentrations were high at the uncontrolled sites and at or near background at the TSCA-landfill. PCBs were detected at low levels in gas vents at the latter site.

0618
Lewis, Robert G. (1986) "Problems associated with sampling for semivolatile organic chemicals in air", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings for the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 134-145. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: VOC, particulate, laboratory, QA, methodology, sampling, literature, EPA$

Semivolatile organic compounds (SVOCs) may be distributed between the gaseous and particulate phases in air. Filtration sampling will not accurately measure particulate organic loadings due to volatilization after collection. When backup vapor traps are added, the samplers may efficiently collect both phases, but will not maintain their integrity. Hence, results will not realistically reflect airborne distributions. Consequently, great care should be exercised in both sampling and data interpretation. Experimental systems have been developed that may provide some insight into the true phase distributions of several SVOCs. However, a practical method for such monitoring is probably not in the immediate future.

0323
Lewis, Robert, G., and MacLeod, Kathryn E. (1982) "Portable sampler for pesticides and semivolatile industrial organic chemicals in air", Anal. Chem., 54:310-315.

KEYWORD: sampling, personal, monitor, pesticides, homes, office, industrial

A battery powered, low volume air sampler utilizing polyurethane foam (PUF) as a trapping medium was developed and evaluated. The sampler provides air flows of up to 4L/min, affording theoretical detection limits of less than 0.1 ug/m3 for most chemicals tested. It is lightweight and portable and operates very quietly, which makes it ideally suited for residential air sampling or as a personal air monitor. Sampling efficiencies were determined for 17 organochlorine pesticides and industrial compounds, 3 polybiphenyl mixtures, and 28 organophosphorus, organonitrogen and pyrethroid pesticides. With few exceptions, these chemicals were trapped efficiently (>75%). A combination of PUF with Tenax GC in a single, reusable sampling cartridge provided for quantitative collection of more volatile compounds.

0652
Lewis, R.G., Mulik, J.D., Coutant, R.W., Wooten, G.W., and McMillan, C.R. (1985) "Thermally desorbable passive sampling device for volatile organic chemicals in ambient air", Anal. Chem., 57:214-219.

KEYWORD: VOC, sampling, personal, exposure, monitor, methodology, laboratory, QA, outdoor, EPA$, field

A passive sampler was developed for short-term, low-level air monitoring. The small, stainless steel device is simply designed and inexpensive. It has a high equivalent sampling rate, is reusable, and is designed for thermal desorption. Under controlled test chamber atmospheres and in actual outdoor and indoor situations, with Tenax GC as the sorbent, the device compared very favorably with active (pump-based) samplers and has much better sensitivity than commercial passive monitors using activated charcoal. Sampling rates were calculated for several volatile organic chemicals. Thermal desorption and analysis afford a 200-fold (or greater) increase in sensitivity over solvent desorption, allowing very short sampling times. The effects of air velocity on performance also were extensively evaluated. Best results were with wind velocity greater than 15 cm/s and less than 900 cm/s. The sampler is not affected by high humidity when used with Tenax GC or other hydrophobic sorbents.

0782
Lewis, R.G., Jackson, M.D., and MacLeod, K.E. (1980) "Protocol for assessment of human exposure to airborne pesticides", U.S. EPA, Health Effects Research Laboratory, Research Triangle Park, NC 27711 (46 pages).

KEYWORD: distribution, pesticide, monitoring, exposure, sampling, methodology, QA, laboratory, EPA$

This protocol reports on methodology that EPA has developed to assure that air samples will give adequate information on the general population's exposure to pesticidal air pollutants. Pumps, sorbents, calibration methods, and preparations necessary for accurate data collections are described. The determination of sampling efficiencies and respiratory exposure is also discussed.

0783
Lillie, Thomas H. (June 1982) "Chlordane in Air Force family housing: a study of houses treated prior to construction," US Air Force Occupational and Environmental Health Laboratory, Brooks Air Force Base, TX 78235 (7 pages). NTIS ADA-121654.

KEYWORD: pesticide, chlordane, ventilation, outdoor, field, home, exposure, source, architecture

Airborne chlordane levels were measured in 2,113 family housing units on four U.S. Air Force installations during the winter and spring of 1981-82. Ventilation ducts were in or below the slab in all of the houses. The soil below the houses was treated with chlordane before the slabs were poured to prevent termite infestation. Airborne chlordane concentrations exceed the action level (5 ug/m3) in only two of the houses. Plans to sample other houses that were treated only prior to construction should be cancelled because the probability of exceeding the action level is extremely low.

0784
Lillie, Thomas H. (1981) "Chlordane in Air Force family housing: a study of houses treated after construction," US Air Force Occupational and Environmental Health Laboratory, Brooks Air Force Base, TX 78235 (8 pages). NTIS ADA-111463.

KEYWORD: pesticide,chlordane, ventilation, temperature, humidity, exposure,field,home,source,outdoor,architecture,sampling,pressure

Airborne chlordane levels were measured in 474 family housing units on seven U.S. Air Force installations during the winter of 1980-81. Ventilation ducts were in or below the slab in 469 houses and in the crawl spaces in 5 houses. All were treated with chlordane by subslab injection or exterior ditching after construction. In 408 houses (86%), chlordane levels were below 3.5 ug/m3, in 56 houses (12%) levels were from 3.5-6.5 ug/m3, and in 10 houses (2%) levels were above 6.5 ug/m3. There was no correlation between the concentration of airborne chlordane and inside or outside temperature, barometric pressure, relative humidity, or the difference between inside and outside temperature. Houses with exhaust ducts in or below the slab did not have significantly higher levels of airborne chlordane than houses with return air ducts in that location.

0520
Lin, C., Anaclerio, R.N., Anthon, D.W., Fanning, L.Z., and Hollowell, C.D. (1979) "Indoor/outdoor measurements of formaldehyde and total aldehydes", U.S. Department of Energy, Office of Buildings and Community Systems, Washington, DC 20585 (10 pages). NTIS LBL 9397.

KEYWORD: sampling, aldehyde, energy, ventilation, energy, office, CH2O, home, microenvironment, laboratory, methodology

When infiltration and ventilation of a building are reduced to save energy, indoor air quality may deteriorate. Formaldehyde and other aldehydes, important indoor air contaminants, were studied as a function of building air exchange rates in public buildings and energy-efficient research houses. Sequential gas bubbling systems were used in conjunction with a pneumatic flow control system for field sampling. Samples were collected simultaneously for formaldehyde and total aliphatic aldehydes, and were analyzed in the laboratory using three different methods. At public buildings, researchers found that concentrations of formaldehyde and aldehydes were about the same indoors and outdoors (due largely to traditionally high ventilation rates in these buildings). However, it is evident that indoor air in general has higher formaldehyde and total aliphatic aldehyde levels than outdoor air. Residential buildings and office trailers, in particular, have levels that can exceed the promulgated European indoor formaldehyde standard of 120 ug/m3 (100 ppb). Because these high air contaminant levels may have adverse health and comfort effects on building occupants, further study is needed to establish ventilation requirements for energy-efficient buildings.

0684
Lindeken, C.L., Jones, D.E., and McMillen, R.E. (1973) "Environmental radiation background variations between residences", Health Phys., 24:81-86.

KEYWORD: radiation, architecture, home, field, exposure,seasonal, outdoor, energy

Environmental background measurements made in approximately 100 residences near Livermore, CA, show variations in annual radiation exposure from 52 to 130 millirems. Measurements were made with calcium difluoride/dysprosium monitors at quarterly intervals for a year. Dwellings were typically wood-frame structures with stucco exteriors. Indoor exposure rates were, on the average, about 25% lower than those outdoors. Dosimeters were used without energy filters because it appears that low energy photons contribute little to the total dose from natural radiation sources. Elimination of energy filters materially simplified packaging and handling requirements for the measurements.

0665
Lioy, Paul J. (1986) "Discussion on guidelines for exposure assessment", Paper no. 86-13.2, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861 Pittsburgh, PA 15230 (8 pages).

KEYWORD: exposure,risk,health,QA,statistical,distribution,model, o utdoor,activity,CO,TEAM,microenvironment,NO2,personal,VOC

The traditional approach to examining relationships between the concentration of a chemical in an environment and the amount available for human ingestion, inhalation or absorption has usually relied on (1) measurements of a pollutant or surrogate at a fixed monitoring location or (2) mathematical model estimates of concentration from effluent emission rates. In the context of the Federal Register guidelines for exposure assessment (November 23, 1984) and the principles currently being applied in the field, these types of data should be used as the basis for preliminary assessments only. Unfortunately, the guidelines do not rigorously express this point. To proceed to an in-depth assessment, pollutant sources, pollutant concentrations, and human activity patterns must be available for discrete microenvironments. Data bases of this sort and exposure models based on them are being developed.

0478
Lipari, F., Dasch, J.M., and Scruggs, W.F. (1984) "Aldehyde emissions from wood-burning fireplaces", Environ. Sci. Technol., 18(5):326-330.

KEYWORD: wood, particulate, CH2O, source, aldehyde, outdoor, acetaldehyde, tolualdehyde, combustion

Total aldehyde emissions from wood-burning fireplaces ranged from 0.6 to 2.3 g/kg of wood burned, based on tests with cedar, jack pine, red oak, and ash. Formaldehyde, acetaldehyde, and p-tolualdehyde were the major aldehydes emitted, with formaldehyde comprising 21 to 42% of the total. Aldehyde and particle emissions were inversely correlated with burn rate and may also be related to wood type. On the basis of these measurements, nationwide aldehyde emissions from residential wood burning were estimated to be between 14 billion and 54 billion grams per year. This value compares to both power plant and automobile aldehyde emissions. It is likely that residential wood burning is a major source of primary aldehydes during the winter.

0697
Lippman, Morton and Lioy, Paul J. (1985) "Critical issues in air pollution epidemiology", Environ. Health Perspect., 62:243-258.

KEYWORD: NAAQS, literature,research, particulate, O3, SO2, health

The epidemiological studies that significantly impacted the setting of National Ambient Air Quality Standards (NAAQS) were performed more than 20 years ago. Most of the more recent studies have been seriously flawed in their design and/or execution because they neglected to account for important variables such as: pollutant exposures other than those from ambient air, influence of personal activity on pollutant uptake, human variability, and the separate contributions of recent transient peak exposures and long-term chronic exposures. For particulates, the influence of composition and size distribution has also received too little consideration. To address these deficiencies, research is needed on: indices for particulate exposures, identification of exposures relevant to the effects, improved indices of effects, acquisition of response data, identification of exposed populations, and identification of susceptible subgroups. Approaches to these needs are discussed, along with brief reviews of several recent studies that have focused on critical issues of concern, made the necessary efforts to characterize the relevant exposures of the populations being studied, and demonstrated human responses to ambient pollutants at current exposure levels.

0515
Lipschutz, R.D., Girman, J.R., Dickinson, J.B., Allen, J.R., and Traynor, G.W. (1981) "Infiltration and indoor air quality in energy efficient houses in Eugene, Oregon", U.S. Department of Energy, Office of Building Energy Research and Development, Washington, DC 20585 (50 pages). NTIS DE82-000971.

KEYWORD: radon, CH2O, NO2, ventilation, exposure, energy, health, home, model, seasonal, smoking, source, architecture

Measurements of infiltration rates and indoor pollutant levels in houses incorporating energy-conserving measures can provide important information about the effectiveness and health effects of such measures. The authors measured 12 energy-efficient houses in Eugene, OR, for effective leakage area using blower door fan pressurization. Air-exchange rates over a period of several hours were determined by tracer gas decay analysis. The results were used (in conjunction with the Lawrence Berkeley Laboratory infiltration model) to predict average annual and heating season infiltration rates. Measured leakage areas and infiltration rates were quite low in comparison to other groups of test houses in North America. Average specific leakage areas for the 12 houses was 2.8 cm2/m2, as compared to 6.4 cm2/m2 for post-1975 California housing. The average heating season infiltration rate was calculated to be 0.34 air changes per hour. Infiltration rates measured from tracer gas decay ranged from 0.08 to 0.27 air changes per hour. Concentration of radon, formaldehyde, and NO2 were measured in four of the houses. Radon levels were insignificant. NO2 concentrations were low in all four houses, although levels in the two houses with smokers were slightly elevated compared to the two houses with nonsmokers. Formaldehyde levels in all four houses were about half of the most restrictive existing guidelines. Furniture and/or building materials are the problem source of this pollutant.

0215
Liu, K.S., Sexton, K., Hayward, S.B., Petreas, M., Webber, L., and Chang, B.-H. (June 1986) "Determinants of formaldehyde concentrations inside mobile homes", Paper no. 86-7.7, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: CH2O, field, source, monitoring, activity, statistical, home, exposure, appliance

In 1984-85, the California Indoor Air Quality Program conducted a State-wide survey of formaldehyde (CH2O) concentrations in mobile homes. Using passive monitors, 1-week integrated levels were measured in kitchens and bedrooms. Information about housing characteristics and activities during the sampling week was gathered with a self-administered questionnaire. Univariate and multivariate analyses revealed the important determinants of indoor CH2O to be home age, open windows, home location, new furniture, and gas appliances.

0214
Liu, K.S., Chang, B. H., Hayward, S. B., Kulasingam, G., and Sexton, K. (June 1986) "Estimation of formaldehyde exposure for mobile home residents", Paper no. 86-68.1, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (15 pages).

KEYWORD: CH2O, field, seasonal, exposure, distribution, source, home, monitoring

In 1984-85, the California Indoor Air Quality program undertook a survey of formaldehyde (CH2O) levels in California mobile homes. Week-long integrated levels were obtained using passive samplers while participants lived normally. During the summer and winter, 470 mobile homes, selected randomly throughout the State, were monitored. More than 500,000 California residents of mobile homes are exposed to CH2O levels greater than 0.05 ppm, about 180,000 residents are exposed to more than 0.1 ppm, and between 730 and 980 residents are exposed to more than 0.4 ppm.

0252
Livingston, J.M., et al. (Sept. 1981) "Living area contamination by chlordane used for termite treatment", Bull. Environ. Contam. Toxicol., 27(3):406-411.

KEYWORD: pesticide, chlordane, exposure, monitoring, field, home

Chlordane contamination was monitored in living areas at a midwestern U.S. Air Force base. The contamination resulted from chlordane treatments for termite control. Airborne chlordane concentrations ranged between 16 and 293 mg/m3. Air sampling data from 1964-79 are tabulated and compared.

0364
Loewenstein, J.C., Pourdel, M.C., Maffiolo, G., Krainik, F., and Wolmark, Y. (1984) "Relation of environmental conditions to the health of the elderly in a long term care hospital, a longitudinal survey", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 275-280. NTIS PB85-104198.

KEYWORD: particulate, NOx,temperature, humidity, health, outdoor, hospital, SO2

This paper presents the first results of a 30-month survey of possible relations of environmental parameters (particulates, SO2, NOx, temperature, humidity, atmospheric pressure), indoors and outdoors, to the health of the elderly in a long-term-care hospital. One of the major results is evidence of an interaction of NOx (the indoor and outdoor values of which are closely correlated) with incidence rates of respiratory disease.

0199

Lorenz, F. (1982) "Calculation of ventilation requirements in the case of intermittent pollution: application to enclosed parking garages", Environ. Int., 8:515-524.

KEYWORD: ventilation,model,energy,control,method,microenvironment

The ventilation requirements for decontamination of indoor air are normally determined with a static calculation method. In some cases, the pollutant emission is intermittent; for example, in the parking garage of an office building, most of the cars enter and leave at nearly the same time. Generally, in such a case, the volume of the garage is large; consequently, the time constant of the system has a high value. So a static approach would no longer be accurate, and a dynamic evaluation is needed. With the help of some assumptions, calculations remain rather simple, and results can be plotted on nomographs or computed on a programmable hand-held calculator. The amount of energy saved may appear very large in some cases. A sizing optimization is required but also remains easy to compute. The paper presents the method of calculation for a single ventilation level and the optimization of a two-level ventilation.

0580

Lowder, Wayne M. (1985) "Radon: overview", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds.,"Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48115, pp. 39-41.

KEYWORD: radon, health, exposure, lung, outdoor, source, risk, literature, epidemiology, research

Naturally occurring radioactive radon is always present in the air. Indoor concentrations are typically 2 to 10 times higher than those in outdoor air. Inhaling radon decay products attached to particulates results in an alpha dose to the critical cells of the respiratory tract, which produces lung cancer in miners. Current estimates of radon exposure and the consequent risk indicate that about 10% of nonsmoking-related lung cancers may be caused by radon. The current literature also hints at a relationship between radon and smoking and the induction of lung cancer. Thus, radon is one of the most significant indoor pollutants in terms of potential adverse human health effects.

0475
Lynch, John J., and Burgess, William A. (1974) "A personal exposure sampler for carbon monoxide", Am. Ind. Hyg. Assoc. J., 35:354-358.

KEYWORD: CO, personal, exposure, monitor, sampling, methodology, QA

The catalytic oxidation of CO to CO2 in air by Hopcalite is the basis for a personal sampler for CO. Four- or 8-hour integrated samples are obtained by drawing air at 0.5 liters per minute (L/M) through stripping beds of Ascarite and molecular sieve, which remove water vapor and CO2 from the ambient air. The air sample then passes to a preweighed glass U-tube that contains Hopcalite, Ascarite, and anhydrous magnesium perchlorate. After sampling, the U-tube is reweighed -- trapped CO2 from the oxidized CO increased the weight of the tube. At 0.5 L/M and 70 degrees F., the 1.5 g of catalyst in the U-tube convert more than 90% of the CO to CO2. For a 4-hour sample in the range of 20 to 100 ppm CO, the relative standard deviation of duplicate measurements is +/- 6%. Duplicate samples were taken in the field for both 4- and 8-hour determinations in the 10 to 100 ppm range, and the precision was +/- 2.4 ppm CO.

0058
Lynn, David, Tabor, Elbert, Ott, Wayne, and Smith, Raymond (June 1967) "Present and future commuter exposures to carbon monoxide", Paper no. 67-5 presented at the 60th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (20 pages).

KEYWORD: CO, field, exposure, vehicle, interior, EPA$

This paper examines efforts by the Federal air pollution research program to better define the exposures of the U.S. population to CO. Efforts to measure the CO exposure of occupants of vehicles moving in traffic, as well as methodologies for predicting future exposures, are described. Summary data are presented from a field study of 14 U.S. cities in which a van equipped with a nondispersive infrared device measured CO exposures on expressways, arterials, and center-city streets. CO exposures ranged from 10 to 29 ppm (average of 19.4 ppm) on expressways, from 15 to 38 ppm (average of 24.6 ppm) on arterials, and from 25 to 40 ppm (average of 31.9 ppm) on center-city streets. With all routes considered, the average exposure ranged from 18 ppm in St. Louis, MO, to 36 ppm in Los Angeles, CA, with an average of 25.4

ppm for all cities.

0038
MacRae, Gordon R., and Arnold, Steve (1984) "Denver carbon monoxide study, fixed station data presentation", draft report, State of Colorado, Department of Health, Air Pollution Control Division, Denver, CO 80203 (est. 160 pages).

KEYWORD: CO, field, personal, exposure, monitor, biomonitoring, outdoor

A description is given of the fixed air-monitoring network that was operated in Denver, CO, at the same time (1982-83) that a personal exposure monitoring study of CO was undertaken. The findings of a study comparing end-expired (breath) air and blood carboxyhemoglobin at high altitudes also are described in Appendix B.

0753
Macher, J., Liu, K.S., and Alevantis, L. (July 1985) "Report on the investigation of air quality in the Disabled Students Services Office at San Fransisco State University", CA/DOH/AIHL/SBS-1, California Department of Health Services, Berkeley, CA 94704 (21 pages).

KEYWORD: CO, CO2, asbestos, ventilation, CH2O, activity, field, office,monitor,temperature,humidity,microorganism,particulate

The California Department of Health Services Indoor Air Quality (IAQ) Program responded to complaints of symptoms, purportedly related to the work environment, among employees in the Disabled Students Services office. In June 1985, the IAQ team visited the office, distributed a work environment/health questionnaire, examined and evaluated the ventilation system, and reviewed the chemicals and cleaners used in the Audio Visual Center (AVC). The IAQ team also collected and analyzed samples for viable particles, airborne pollen grains, formaldehyde, and asbestos; and monitored CO, CO2, respirable dust, air temperature, and relative humidity. These air quality parameters were adequate on the day that they were measured. However, flaws in the ventilation system might allow excessive accumulation during cold weather of unidentified chemicals from the AVC.

0728
Macher, J.M., Alevantis, L.E., Liu, K.S., and Hayward, S.B. (1986) "Report on a preliminary investigation of air quality in the Richmond Health Clinic", CA/DOH/AIHL/SBS-2, California Department of Health Services, Berkeley, CA 94704 (9 pages).

KEYWORD: office, research, exposure, ventilation, health, field, personal

This report summarizes an investigation by the California Department of Health Services of a complaint by health clinic staff concerning air movement within their offices and possible health effects. Samples were collected of (1) the salt solution used to dehumidify the air, (2) dust on furniture and in the air filters, (3) water in the air handling unit and (4) non-carbon producing paper used in the office. The investigation recommended steps to reduce potential contaminant sources, and to evaluate the problem more fully. These included to drain the x-ray film developer, fix the corroded x-ray developer drain pipe, replace or clean the materials that were contaminated by the pipe leak, check the ventilation flow rates, install low cost ceiling fans if needed, and conduct surveys to determine health effects of the dehumidifier, biological air contaminants, and noncarbon producing paper.

0121
Mack, G.A., Pope, A.M., and Howes, J.E., Jr. (1983) "Carbon monoxide monitoring in microenvironments in the Washington, DC area", EPA contract No. 68-02-3745, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (162 pages). Not available from NTIS.

KEYWORD: CO,microenvironment,personal,exposure, monitor, vehicle, interior, outdoor, EPA$, office

Data on CO exposures to individuals were collected for the microenvironments associated with (1) several methods of commuting to and from work, (2) working in a large office building in an urban area, and (3) shopping in a commercial area in a large metropolitan city. The study was conducted in the Washington, DC, area from January 7 through March 18, 1983. A new personal monitoring system was used consisting of a CO detector linked to an automatic data-logging system. Methods and results are thoroughly described for each microenvironment.

0602
Mage, D.T., and Wallace, L.A., Eds. (1979) "Proceedings of the symposium on the development and usage of personal monitors for exposure and health effects studies", U.S. EPA, Office of Research and Development, Research Triangle Park, NC 27711 (518 pages). NTIS PB80-143894.

KEYWORD: personal, exposure, monitor, health, methodology, EPA$, sampling, QA, biomonitoring, epidemiology

These are the proceedings of a symposium on the development and usage of personal monitor for measuring pollutant exposures and resultant physiological responses. This report contains edited transcripts of the discussion following each paper, the transcript of an informal general discussion period, and the transcript of a closing panel discussion. The breakthroughs in miniaturization of data processing and control modules through the use of digital microcircuitry have allowed the development a new generation of pocket-sized personal monitors for both pollution variables and physiological measures. The symposium addressed the conduct of epidemiological and exposure assessment studies that incorporate these monitors into the design.

0042
Mage, David T.(1985) "Concepts of human exposure assessment for airborne particulate matter", Environ. Int., 11:407-411.

KEYWORD: particulate, model, personal, monitoring,exposure, risk, EPA$

This paper discusses how human exposures to airborne particulates can be determined from personal monitoring and estimated by ambient monitoring and microenvironmental monitoring. The utility of each approach is discussed, and examples are given of applications to assessments of human exposures for purposes of relating these exposures either to measures of health or risk assessments of these exposures.

0428
Mage, David T., and Gammage, R.B. (Oct. 1984) "Evaluation of changes in indoor air quality occurring over the past several decades", Gammage, R.B., and Kaye, S.B., Eds., "Indoor air and human health", Lewis Publishers, Inc., Chelsea, MI 48118, pp. 5-35.

KEYWORD: CO2, VOC, smoking, source, exposure, literature, health, outdoor, SO2, NO2, particulate, activity, radon, CH2O

The history and probable future of the study of indoor air quality (IAQ) are discussed. Since World War II, increased indoor air pollution sources and energy conservation measures as well as decreased indoor/outdoor air exchanges have caused IAQ to deteriorate. In recent years, public and governmental concern over the health effects of indoor air pollution has intensified. Improvements in analytical methodology permit more accurate assessments of IAQ. The authors discuss a wide variety of indoor air pollutants with regard to the above concerns.

0144
Mage, David T., et al. (April 1985) "Human exposure assessment location (HEAL) project: United States component", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (201 pages). Not available from NTIS.

KEYWORD: HEAL, TEAM, methodology, sample, design, multipollutant, multimedia, distribution, outdoor, VOC,biomonitoring, EPA$, QA

The Human Exposure Assessment Location (HEAL) project is coordinated by the United Nations Environment Programme and is designed to provide direct data on exposure to pollutants. These data will supplement multimedia ambient and source monitoring. The U.S. contribution, by the U.S. EPA, is to develop and demonstrate methodologies for (1) determining frequency distributions of personal exposures of a statistically valid sample population to pollutants in air, drinking water, and food, (2) determining frequency distributions of pollutant concentrations in breath, blood, urine, and tissue (body burden), (3) relating Number 1 to Number 2, (4) relating Number 1 to measurements in ambient air and food, and (5) determining important sources of exposure. This report screens methodologies for HEAL suitability and also screens pollutants on the basis of methodology availability. HEAL overlaps the Total Exposure Assessment Methodology (TEAM) project. Data quality assurance is discussed.

0337
Maki, H.T., and Woods, J.E., Jr. (1984) "Dynamic behavior of pollutants generated by indoor combustion", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 73-78. NTIS PB85-104222.

KEYWORD: CO2, source, ventilation, humidity, home, temperature, NOx, combustion, laboratory, kerosene

When indoor air concentrations from indoor combustion processes are estimated, source strengths and ventilation rates are usually considered. Recent studies, conducted in the Energy Research House at Iowa State University, indicate that several other factors also have a significant effect on indoor air concentrations. In one of these studies, a ventless kerosene heater served as the source of pollutants. Resultant concentrations of NOx and CO2, as well as relative humidity and air temperatures, were monitored throughout the house. An inert tracer gas, SF6, was released in the house at the same points as the pollutant concentrations. The authors concluded that, in nonsteady conditions, it is not valid to assume that pollutants from a local source disperse uniformly throughout a house. To the contrary, various pollutants are dispersed at various rates, and additional research should be directed to these dynamic behavioral characteristics.

0348
Malaspina, J., Bodilis, H., Giacomoni, L., and Marble, G. (1984) "Indoor air pollution: study of two buildings in the Paris area", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 499-504. NTIS PB85-104222.

KEYWORD: smoking, SO2, microorganism, outdoor, multipollutant, exposure, foreign, France, particulate, office

A study measured thoroughly the levels of indoor chemical and particulate pollution in two tall office buildings in the Paris, France, area. For one building, the measurements were made at the same time in the open air, and a study of aerobiocontamination was added. The results show that the levels of most of the pollutants were higher inside than outside, the outstanding exception being SO2. Tobacco smoke was found to be the main source of pollution.

0256
Males, R. (Sept. 1984) "R&D status report: indoor air quality", Electric Power Research Institute J. 15:45-47.

KEYWORD: literature, outdoor, smoking, NO2, CO, particulate, personal, exposure, monitor, CH2O, radon, energy, health

This report reviews why the Electric Power Research Institute (EPRI) is interested in indoor air quality (IAQ) and summarizes several EPRI-funded studies. Of special interest are the effects on IAQ of utility-sponsored house weatherization programs, the health effects of indoor pollutants that also are generated by EPRI utilities, and the effects on IAQ of different heating, air conditioning, and appliance technologies.

0624
Martonen, T. (1983) "Deposition of inhaled particulate matter in the upper respiratory tract, larynx, and bronchial airways: a mathematical description", Journal of Toxicology and Environmental Health. 12:787-800.

KEYWORD: aerosol, distribution, health, model, particulate, lung, dose

A mathematical description of inhaled particle behavior suitable for analysis of factors affecting deposition in the human upper respiratory tract, larynx, and ciliated airwarys is presented. In this model, particle losses in the upper respiratory tract are described by empirical formulas. In downstream bronchial airways, particle deposition probabilities are calculated using a system of theoretical equations that describe the behavior of aerosol air flow known to exist in the human lung. Results indicate that the model effectively simulates factors affecting particle motion in respiratory passages. It is proposed that this model could be used to evaluate health effects of hazardous aerosols.

0360
Matsuki, H., Yanagisawa, Y., Osaka, F., Kasuga, H., and Nishimura, H. (1984) "Personal exposure to NO2 and its health effect with urinary hydroxyproline to creatinine ratio as biochemical indicator", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 243-248. NTIS PB85-104198.

KEYWORD: personal, exposure, monitor, NO2, biomonitoring, health, source,statistical,model,foreign,smoking,Japan,seasonal

The relation between personal NO2 exposure and the ratio of urinary hydroxyprolien to creatinine (H/C) was examined in winter and summer. Subjects were from families of students attending primary schools in the Tokyo, Japan, metropolitan region. Integrated 24-hour personal NO2 exposures were determined with triethanolamine-coated cellulose badges and subsequent colorimetric analysis. Hydroxyproline and creatinine were determined by modified auto-analyzer procedures. Results of step-wise multiple regression are presented for (1) personal NO2 exposure, (2) active smoking level, (3) passive smoking level, (4) age, (5) occupation, (6) home location, and (7) distance from the home to a busy road. A linear model was developed to predict the effects of these parameters on H/C.

0232
Matsukuru, Shiegeru, et al. (Sept. 1984) "Effects of environmental tobacco smoke on urinary cotinine excretion in nonsmokers", New Eng. J. Med., 311(13):828-832.

KEYWORD: biomonitoring, passive, smoking, rural, exposure, home, foreign, Japan

The relationship between excretion of urinary cotinine (the major metabolite of nicotine found in urine) in 472 nonsmokers and the smokiness of their environment is investigated. The presence of smokers in both the home and workplace increased the cotinine levels, and urban nonsmokers had more cotinine in their urine than did rural smokers. The deleterious effects of passive smoking may occur in proportion to the exposure of nonsmokers to smokers in the home, workplace, and community.

0367
Matsushita, Hidetsaru, and Mori, Tadashi (1984) "Nitrogen dioxide and nitrosamine levels in indoor air and side-stream smoke of cigarette", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 335-341. NTIS PB85-104198.

KEYWORD: NO2, outdoor, personal, exposure, monitor, home, office, source, seasonal, smoking, foreign, Japan

Personal exposures to NO2 dioxide for about 40 volunteers living in Tokyo, Japan, ranged between 13 and 132 ppb in winter, 8 and 53 ppb in spring, 6 and 28 ppb in summer, and 8 and 37 ppb in autumn. They spent most of their time indoors--office workers 22.0 to 23.0 hours a day, and nonworking women 22.0 to 22.6 hours. NO2 concentration in homes was remarkably high in winter as compared with that outside homes, indicating a large contribution of heating to NO2 indoor air pollution. Personal exposures correlated well with indoor pollution, especially home indoor pollution. N-nitrosodimethylamine and N-nitrosopyrolidine in side-stream smoke ranged from 180 to 427 and 76 to 206 (respectively) ng/cigarette for Japanese cigarettes and from 264 to 544 and 114 to 332 (respectively) ng/cigarette for both English and American cigarettes. These nitrosamines were detected in some indoor environments such as offices, coffee shops, and pinball houses.

0233
Matthews, T.G., et al. (May 1984) "Practical measurement technology for low-formaldehyde-concentration levels: applications to personnel monitoring needs", EPA National Symposium on Monitoring Hazardous Organic Pollutants in Air, Raleigh, NC. NTIS PB84-148345.

KEYWORD: CH2O, regulation, personal, exposure, monitor, source, methodology, home

A formaldehyde (CH2O) monitoring program has been developed at Oak Ridge National Laboratory to assist the Consumer Product Safety Commission in its deliberations concerning the use of urea-formaldehyde foam insulation materials and the possible development of an indoor air quality standard for CH2O. Low-cost monitoring technology has been developed for a large-scale screening analysis of CH2O levels in dwellings and for inspection instrumentation that operates at near real-time speed. The applicability of the new methodologies to personnel monitoring needs, including area monitors, personnel badges, and near real-time measurement techniques, is under investigation.

0254
Matthews, T.G., et al. (Nov. 1981) "Visual colorimetric formaldehyde screening analysis for indoor air", J. Air Pollut. Control Assoc., 31(11):1181-1184.

KEYWORD: CH2O, temperature, methodology, laboratory, field

A visual colorimetric analysis method for screening formaldehyde at levels of about 100 ppb is demonstrated. The method, based on the general aldehyde methylbenzothiazolin-hydrazone technique, is insensitive to variations of 15% in reagent concentration and ambient temperatures between 14 and 26 degrees Celsius. Field tests show that the method is well suited for screening formaldehyde in homes.

0570
Matthews, T.G., Fung, K.W., Tromberg, B.J., and Hawthorne, A.R. (1986) "Surface emission monitoring of pressed-wood products containing urea-formaldehyde resins", Environ. Int., 12(1-4):301-309.

KEYWORD: CH2O, exposure, field, methodology, QA, source, model, temperature, humidity, architecture, home, laboratory

Emission rates of formaldehyde (CH2O) from U.S.- manufactured particleboard, hardwood plywood paneling, and medium-density fiberboard products were surveyed using a formaldehyde surface emission monitor (FSEM). The results indicate approximately two orders of magnitude variation in CH2O emission rates between weakly emitting paneling and strongly emitting fiberboard products. The CH2O emission rates for particleboard, paneling, and fiberboard products average 0.30, 0.17, and 1.5 mg/m2h, respectively. Sources of variation in emission rates were investigated. The relative intraboard, interboard, and intermanufacturer variation observed varies strongly between particleboard, paneling, and fiberboard product categories. The FSEM was also used carpet-covered particleboard underlayment in two unfurnished research homes. Measurements were made at 16 different temperature and relative humidity (RH) conditions ranging from 17 to 29 degrees C and 41% to 88% RH to field-test the response of the FSEM under variable environmental conditions. Substituting the FSEM CH2O emission rate data into a simple steady-state, CH2O concentration model (that does not account for variation in temperature and RH) gave good agreement between FSEM-modeled and measured CH2O concentrations.

0635
Matthews, T.G., Fung, K.W., Tromberg, B.J., and Hawthorne, A.R. (1986) "Impact of indoor environmental parameters on formaldehyde concentrations in unoccupied research houses", J. Air Pollut. Control Assoc., 36:1244-1249.

KEYWORD: CH2O,source,exposure,model, field,humidity, temperature, seasonal, home, laboratory

This study examined the impact of indoor temperature (T) and relative humidity (RH) levels on formaldehyde (CH2O) concentrations inside two unoccupied research houses where the primary CH2O emitter is particle board underlayment. The data were fit to a simple, three-term, steady-state model describing the T and RH dependence of CH2O concentration in a single compartment with a single CH2O emitter. The model is used to estimate potential seasonal variation in CH2O concentrations under specified experimental conditions inside the houses. The research house data also were used to evaluate the limitations and applicablility of more complex five-term models developed from small-scale chamber studies of the environmental dependence of CH2O emissions from particle board underlayment. These models also incorporate a linear T and RH dependence of the CH2O transport rate through the emitter as well as the T and RH dependence of CH2O concentrations within the emitter. The research house results correlated well with (1) a single underlayment model over a broad range of environmental conditions and (2) a multiple underlayment model over a restricted range of environmental conditions.

0255
Matthews, T.G., Reed, T.J., Tromberg, B.J., Daffron, C.R., and Hawthorne, A.R. (1984) "Formaldehyde emissions from consumer and construction products: potential impact on indoor formaldehyde concentrations", Oak Ridge National Laboratory, Oak Ridge, TN 37831 (8 pages). NTIS DE-84016592/XAB.

KEYWORD: CH2O, home, exposure, source, combustion, architecture, model

The formaldehyde (CH2O) emission rates of combustion sources and construction products commonly found in homes are surveyed. The potential impacts of these sources on indoor CH2O concentrations are estimated using simple steady-state, indoor pollutant concentration models. The strongest contributors to indoor CH2O are pressed-wood products and foam insulation containing urea-formaldehyde resins.

0525
Matthews, T.G., Hawthorne, A.R., Schrimscher, J.M., Corey, M.D., and Daffron, C.R. (1983) "Formaldehyde surface emission monitor", Proceedings at: National symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982", pp. 30-43. NTIS PB84-148345.

KEYWORD: source, QA, methodology, sampling, emission, laboratory, CH2O, architecture

A monitor is being developed for passive, nondestructive measurement of formaldehyde emission rates from flat surfaces of solid formaldehyde sources. The monitor uses a solid sorbent, 13X molecular sieve, that provides excellent chemical stability for sorbed formaldehyde and can be used in any physical orientation, with a 0.032 m2 test area. A detection limit of 0.01/mg formaldehyde/m2/hr can be achieved with a 3-hour sampling period and pararosaniline colorimetric analysis. Preliminary results indicate that the monitor could be used for (1) quality control measurements of commercial formaldehyde - containing materials such as pressed-wood products and (2) in-situ measurements of formaldehyde emission rates from a variety of sources in domestic environments such as pressed wood, textiles, and urea-formaldehyde foam insulation products.

0685
Matthews, T.G. (1982) "Evaluation of a modified CEA Instruments, Inc. Model 555 analyzer for the monitoring of formaldehyde vapor in domestic environments", Am. Ind. Hyg. Assoc. J., 43:547-552.

KEYWORD: CH2O, field, temperature,home, methodology,QA, humidity, exposure, monitoring

The experimental design, chemical reagents, and operational protocol for a CEA Instruments Model 555 analyzer were modified to optimize the performance of the instrument for formaldehyde (CH2O). The improved sensitivity and reliability of the modified instrument enhanced its suitability for quasi-real-time monitoring of domestic environments with low CH2O levels (0.01-0.2 ppm). Calibration data taken at sub-0.1 ppm yielded a detection limit of approximately 0.01 ppm. The instrument is insensitive to changes in humidity, but demonstrates a serious temperature dependence between 16 and 38 degree C. Calibration data taken at room temperature are applicable between 16 and 28 degrees C. if a specific operational protocol is observed. Field results taken in three dwellings with low CH2O levels were reported. The modified CEA Instrument compared favorably with an environmentally controlled, reference, air-sampling unit.

0171
Matthews, T.G., Hawthorne, A.R., Howell, T.C., Metcalfe, C.E., and Gammage, R.B. (1982) "Evaluation of selected monitoring methods for formaldehyde in domestic environments", Environ. Int., 8:143-151.

KEYWORD: CH2O, monitoring, home, methodology, laboratory, field, QA

Various methodologies for monitoring formaldehyde (CH2O) in domestic environments have been developed and evaluated. A modified CEA Instruments, Inc., analyzer has near-real-time CH2O-specific analysis capability with an 0.01- mg/m3 detection limit. A solid sorbent 13X molecular sieve has been used in a pumped collection unit with a demonstrated linear dynamic range of 0.03 to 12.5 mg/m3 using sampling periods of less than 15 minutes. The development of screening-type techniques has included (1) a semipermeable-membrane passive sampler for measurements of average CH2O concentration over 8 to 24 hours and (2) a visual colorimetric method for semiquantitative determination of CH2O using solid chemical reagents. A preliminary field evaluation showed excellent agreement between the new CH2O monitoring methods and a reference sampling and analysis technique. An apparatus to produce CH2O vapor is also reported with a demonstrated linear dynamic range of 0.003 to 12.5 mg/m3.

0629
Matthews, T.G., Reed, T.J., Tromberg, B.J., Daffron, C.R., and Hawthorne, A.R. (1984) "Formaldehyde emissions from combustion sources and solid formaldehyde resin containing products: potential impact on indoor formaldehyde concentrations", NTIS DE 84 011630.

KEYWORD: CH2O, activity, combustion, home, architecture, model, source

The formaldehyde emission rates of combustion sources and solid formaldehyde resin-containing products commonly found in homes are surveyed. The potential impact of these sources on indoor formaldehyde concentrations is estimated using simple steady-state, indoor pollutant concentration models. Source emission rates, product loadings for solid emission sources, operation cycles for combustion sources, and potential permeation barriers are considered in the model. The study concludes that the strongest contributors to indoor formaldehyde are pressed-wood products and foam insulation containing urea formaldehyde resins. Combustion sources and phenol-formaldehyde resin-bonded products are generally weak emitters.

0302
McAulay, I.R., and McLaughlin, J.P. (1985) "Indoor natural radiation levels in Ireland", Sci. Total Environ., 45:319-325.

KEYWORD: radon, radiation, methodology, home, exposure, source, foreign, Ireland, architecture

A preliminary study of indoor radiation levels in Ireland is presented. During 1983-84, measurements were made in more than 250 houses. Most measurements were made using passive devices: thermoluminescent detectors for penetrating radiation, and CR-39 alpha track plastic detectors for radon. The median value of the doses from penetrating radiation was 0.78 milligray/year (mGy/Y) with a maximum value of 1.47 mGy/Y detected. Radon showed a large degree of variability with a median value of 43 Becquerels per cubic meter (Bq/m3). About 10% of the houses had radon air concentrations in excess of 100 Bq/m3 with a recorded maximum of 700 Bq/m3. A tentative analysis of the data with regard to the geological situation is presented.

0486
McCarthy, Sharon M., et al. (1986) "Evaluation of indoor air quality data for making risk assessments", Final draft report under RP 1948-1, Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, CA 94303 (162 pages).

KEYWORD: NO2,CH2O,radon,smoking,personal, home, risk, combustion, architecture,energy,exposure,health,outdoor,research,weather

This study evaluates the data available to make risk assessments for the changes in indoor air quality produced by weatherization of homes and the potential health effects of pollutants in the types of structures most likely to be weatherized -- residential single- or multi-family housing. Sources and health effects of radon, formaldehyde, NO2, and tobacco smoke are reviewed. In addition, structural variables and weather factors that affect air exchange rates are discussed. Exposure, dose response, and risk assessment are discussed for each pollutant and recommendations are presented for further study.

0356
McCarthy, S.M., Colome, S.D., and Spengler, J.D. (1984) "Indoor and outdoor aerosols: a multivariate approach to source

identification", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 195-200. NTIS PB85-104198.

KEYWORD: particulate, SO2, NO2, home, outdoor, exposure, field, source, statistical, aerosol

Respirable particles, SO2, and NO2 were collected inside and outside of five residences in the rural farming community of Portage, WI. Elemental characterization of the particles was neutron activation analysis. Meteorological parameters were measured also. The data were analyzed using the multivariate technique of cluster analysis, which provides an overview structure of the data by assigning elements to groups. The outdoor and indoor data were analyzed separately on a site-by-site basis. The major findings are (1) the components of the outdoor and indoor clusters are similar, (2) the association of elements indoors is weaker than outdoors, and (3) the identification of an indoor source is possible when it is strong and/or has unique elemental markers (e.g., a wood stove). The application of cluster analysis is unique in the field of elemental aerosol data and provides a framework to examine multivariate data.

0120
McCormick, R.A., and Xintaras, C. (1962) "Variation of carbon monoxide concentrations as related to sampling interval, traffic and meteorological factors", J. Appl. Meteorol., 1(2):237-243.

KEYWORD: CO, sample, design, vehicle, weather, outdoor

Diurnal variations of CO concentrations and traffic density, exemplified in the literature as common for urban areas, were observed at "curb-side" studies in Nashville, TN, and Cincinnati, OH. A new technique is suggested for evaluating the effect of changes in traffic density on CO concentrations, which may be useful for urban planning and for understanding how wind speed modifies these evaluations. Peak-to-mean ratios of CO concentrations at Cincinnati were in the same range, 2:1-3:1, as those reported in single-source experiments in open terrain in which the source and receptor were located at the same height. In both cities, the short-period CO concentrations fluctuated less rapidly than in single-source cases. Multiple and indefinite sources of CO in the immediate area of the urban sampling sites undoubtedly account for this by providing continuous CO contamination.

0681
McGregor, R.G., Vasudev, P., Letourneau, E.G., McCullough, R.S., Prantl, F.A., and Taniguchi, H. (1979) "Background concentrations of radon and radon daughters in Canadian homes", Health Phys., 39:285-289.

KEYWORD: radon, statistical,design, home,source, field, exposure, foreign, Canada

Radon and radon daughters were measured in 14 Canadian cities on 9,999 homes selected in a statistically random manner. The geometric means of the different cities varied from 0.14 to 0.88 picoCuries/liter (pCi/l) for radon and 0.0009 to 0.0036 Working Levels for radon daughters. The radon originated from natural radioactivity in soil surrounding the homes.

0303
McGregor, R.G., Walker, W.B., and Letourneau, E.G. (1985) "Radon and radon daughter levels in energy efficient housing", Sci. Total Environ., 45:271-278.

KEYWORD: radon,foreign, energy, Canada, home, exposure, seasonal, architecture

Radon and radon daughter concentrations have been measured in 33 "energy-efficient" homes in a small subdivision in Kanata, Ontario. Integrated radon measurements were determined during 3-month periods for a year using solid-state nuclear track detectors. Radon and radon daughter grab samples analyzed during corresponding periods confirm the distributions of the integrated radon measurements. Annual average individual home radon concentrations show an 8-fold range between homes. This variability in radon concentrations is not reflected in the range of air exchange rates for the homes. A distinct seasonal variation is noted for the median values of the radon and radon daughter concentrations and the equilibrium factor in the dwellings.

0118
McIvaine, P.M., Nelson, W.C., and Bartlett, D., Jr. (1969) "Temporal variation in carboxyhemoglobin concentration", Arch. Environ. Health, 19:83-102.

KEYWORD: CO, field, smoking, biomonitoring

Carboxyhemoglobin (COHb) concentrations were measured in 15 subjects by analysis of alveolar air samples collected at 2-hour intervals during waking hours on 7 consecutive days. Overall mean values were 3.80% COHb for five cigarette smokers and 1.64%

for ten nonsmokers. Analysis of the results indicates that long-term average COHb levels can be estimated with fair reliability from two or more instantaneous samples for each subject. This technique may be useful in estimating chronic CO exposures for epidemiologic studies.

0027
McKenzie, R.L., Bright, D.S., Fletcher, R.A., and Hodgeson, J.A. (1982) "Development of a personal monitor for two sizes of inhalable particulates", Environ. Int., 8:229-233.

KEYWORD: particulate, personal, exposure, monitor, methodology

Measurement of personal exposure to ambient levels of particulates is often extremely difficult because of a lack of personal exposure monitors capable of collecting measurable quantities within a meaningful sampling period. A new personal monitor for two fractions of inhalable particulates -- that is the fraction with aerodynamic diameters of 3-15 um and the respirable fraction (under 3 um) -- has been developed and characterized. This monitor can collect a sample of each fraction that is quantifiable with ambient concentrations as low as 23 ug/m3 in a 24-hour sampling period. Wind tests were made on the monitor to determine sampling efficiency as a function of relative wind speed and direction.

0110
McNall, Preston E. (May 1985) "Indoor air quality modeling workshop report", National Bureau of Standards, Gaithersburg, MD 20899 (11 pages). NTIS PB85-212306.

KEYWORD: model, research, control, multipollutant, EPA$

Comprehensive modeling of emission, adsorption, movement, and controls of indoor air contaminants is essential for developing national policy for indoor air quality (IAQ) assessment and controls. This report describes several topics discussed in a workshop on indoor air quality, which was held on February 11, 1985, at the National Bureau of Standards (NBS). Researchers on IAQ modeling were invited to state their current activities, identify future research needs, and recommend specific parameters and contaminants to be included in the IAQ models. This input will be incorporated in an advanced simulation model for IAQ to be developed by NBS under a contract with EPA.

0275
McNall, Preston, et al. (Oct. 1985) "Indoor air quality modeling phase 1 report: framework for the development of general models",

NBSIR 85-3265, National Bureau of Standards, Gaithersburg, MD 20899 (55 pages). NTIS PB86-166626.

KEYWORD: CH2O, NOx, CO2, radon, CO, weather, architecture, model, smoking, particulate, source, EPA$

This report presents a framework for the development of a model for predicting the indoor air pollutant concentrations in a variety of building types under practical conditions of weather, building occupancy, building construction, and pollutant source strength. The general concepts needed for developing an indoor air quality model are treated. Examples of the current state of indoor air quality models are given. The pollutants discussed are formaldehyde, radon, NOx, tobacco smoke, particulates, CO2, and CO.

0140
McNelis, David N., Barth, Delbert S., Khare, Meena, LaPoint, Thomas W., and Yfantis, Evangelos A. (April 1984) "Exposure assessment methodologies for hazardous waste sites", report under cooperative agreement no. CR-810550-01, U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, NV 89154 (217 pages). Not available from NTIS.

KEYWORD: multipollutant, economic, source, model, exposure, statistical, methodology, QA, EPA$

A uniform approach and procedure are presented for estimating exposures to important receptors from defined hazardous waste constituents via all important exposure pathways. The efficient use of resources and information and the need for exploratory programs are emphasized. Cost-cutting statistical methods are referenced as well as required quality assurance and security procedures to ensure the reliability and utility of the data for EPA law enforcement actions. Applicable and available theoretical and empirical models are described in sufficient detail to ease decisions regarding their use in designing and conducting an exposure assessment program. Finally, a case study summarizes the suggested methodologies.

0358
Meckler, Milton (1984) "Analysis of low particulate size concentration levels in office environments", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 209-214. NTIS PB85-104198.

KEYWORD: particulate, office, ventilation, exposure, field, model, methodology, statistical

Simulation methods and test results are presented to confirm projections of actual total suspended particulate (TSP) concentrations for representative office buildings, with emphasis on particles in the 0.3-to-5-micron range. Problems resulting from oversimplified assumptions inherent in ventilation regulations also are discussed. Novel methods that permit simulation and analysis using both one- and two-compartment models are described. These methods are based on an iterative numerical integration algorithm that permits evaluation of the net internal generation rate of TSP for a given distribution by particle size. The rates are evaluated using the differential form of the mass balance equation for the steady-state solution. Results are presented for known and simulated TSP distributions in the working spaces, without neglecting sorption and settling effects. The resulting computer model permits projections of actual contamination levels, accounting for dilution effects under various ventilation conditions in the representative office environments.

0150
Meisel, W.S., and Dushane, T.E. (Oct. 1977) "Monitoring carbon monoxide in urban areas", Technology Service Corp., 2811 Wilshire Blvd., Santa Monica, CA 90403 (135 pages). NTIS PB-296493/LL.

KEYWORD: CO, vehicle, monitoring, methodology, source, seasonal, statistical

It had been assumed that an environmental impact statement for a proposed highway requires 1 year of monitoring to estimate the annual second highest 8-hour CO maximum and the annual second highest 1-hour CO maximum. However, the 8-hour maximum can be extrapolated from as little as 1 month of CO sampling using existing CO auxiliary data, existing meteorological data, or no auxiliary data at all. The key result of the study is that such an extrapolation is valid, even without auxiliary data, if a CO season of October-January (and possibly February) is monitored. The 1-hour second highest maximum is then estimated from the 8-hour second highest maximum using an empirically derived linear regression. The confidence intervals of the error are comparable with the intrinsic variability of the annual statistics estimated. Data were obtained from primary locales, Los Angeles, CA, and Newark, NJ, for development of methodologies and comparison. Data from secondary locales, San Francisco, CA, Denver, CO, and St. Louis, MO, were used to verify the methodologies developed and to extend results or confidence levels to a broader geographic area.

0299
Melcher, R.B., Garner, W.L., Severs, L.W., and Vaccard, J.R. (Feb. 1978) "Collection of chlorpyrifos and other pesticides in air on chemically bonded sorbents", Anal. Chem., 50(2):251-255.

KEYWORD: chlorpyrifos, health, ronnel,lindane,carbaryl, diazinon, pesticide, methodology, sampling, model, field

A procedure is described for collecting and determining chlorpyrifos and other pesticides in air at the low-ppt level for sampling periods ranging from 10 minutes to 16 hours. Worker breathing-zone samples were collected by pumping air through a small tube containing a chemically bonded sorbent. Samples were analyzed by desorption in diethyl ether and injection into a gas chromatograph equipped with a poly 1-100 column and an electron capture detector. Preliminary results for ronnel, lindane, carbaryl, and diazinon showed that this technique is applicable to a wide range of pesticides.

0234
Melia, R.J.W., et al. (1978) "Differences in NO2 levels in kitchens with gas or electric cookers", Atmos. Environ., 12(6-7):1379-1381.

KEYWORD: NO2, source, personal,exposure,monitor, home, appliance, methodology

The reliability of a small personal sampler for NO2 measurements is tested. Levels measured in kitchens with gas and electric cookers are contrasted. The higher concentration of NO2 in gas kitchens, if maintained, would lead to levels above the maximum annual arithmetic mean of 50 ppb recommended in the primary National Ambient Air Quality Standard.

0294
Melius, J., Wallingford, K., Carpenter, J., and Keenlyside, R. (1984) "Indoor air quality: the NIOSH experience (evaluation of environmental office problems)", Am. Conf. Indust. Hyg. Report, 10:3-7.

KEYWORD: NIOSH, monitoring, ventilation,pesticide, field, office, source, architecture

Health complaints associated with poor indoor air quality have been reported with increasing frequency among office workers during the past decade. Through December 1983, the National Institute for Occupational Safety and Health has completed 203 health evaluations involving indoor air quality in a variety of settings. Most evaluations were conducted in governmental or private offices. Inadequate ventilation was blamed for poor air in approximately 50% of the evaluations. Other types of problems stemmed from contamination from inside or outside the building or contamination from the building materials themselves.

0601
Mendez, W. M., Kolsky, K. B., and Gibbs, M. C. (1983) "Mini-assessment: total exposure assessment and exposure-dose relationships", U.S. EPA, Office of Research and Development, Washington, DC 20460 (158 pages). NTIS PB84-128032/REB.

KEYWORD: literature, personal, exposure, TEAM, biomonitoring, microenvironment, model, demographic, activity, methodology, EPA$

This report provides a brief examination of (1) recent research in the areas of total exposure assessment and (2) research concerning the relationship between patterns of exposure to environmental pollutants and dose levels received by exposed individuals and populations. This assessment is intended to provide policy makers with a brief, concise discussion of important trends in recent research; it is not meant to be a comprehensive literature review.

0569
Meyer, Beat (1986) "Formaldehyde exposure from building products", Environ. Int., 12(1-4):283-288.

KEYWORD: CH2O, source, field, laboratory, regulation, seasonal, home, ventilation, diurnal, temperature, humidity, architecture

Formaldehyde (CH2O) is released from building products primarily due to incompletely reacted urea-formaldehyde resin in particleboard, medium density fiberboard, and plywood. CH2O is also released from urea-formaldehyde foam insulation that was popular during the 1970s for retrofitting buildings. The study of commercial adhesives and urea-formaldehyde-bonded wood products shows that current state-of-the-art products yield air chamber test values below 0.25 mg/m3 immediately after manufacture and can meet the 0.12 mg/m3 CH2O indoor air standard unless these products are used where they are exposed to high temperature and humidity. In mobile homes in severe climates, wall-temperature profiles show large seasonal and diurnal variations that cause large changes in CH2O indoor levels. The results show that diurnal CH2O levels may change by a factor of 5 in 24 hours. Therefore, CH2O exposure levels in mobile homes depend on daytime conditions.

0224
Meyer, B., and Hermanns, K. (1985) "Diurnal variations of formaldehyde exposure in mobile homes", J. Environ. Health, 48(2):57-61.

KEYWORD: CH2O, temperature, source, exposure, field, seasonal, weather, architecture, model, home

Recent field studies have revealed substantial diurnal variations of formaldehyde concentrations in mobile homes that are exposed to sun radiation or warm weather. This effect is related to diurnal variations in indoor wall temperatures. Observed formaldehyde levels correlate closely to levels calculated from laboratory emission data for wall paneling and flooring. The significance of diurnal variations is demonstrated by model calculations of time-weighted formaldehyde exposure levels for homemakers and their working spouses living in high-emitting and low-emitting mobile homes under climatic conditions that correspond to summer 1981 weather in three cities. Homes containing low-emitting wood products can meet ambient 0.1-ppm standards under most conditions, while high-emitting products will cause odor problems and yield formaldehyde levels that may be close to occupational standards.

0170
Miksch, R.R., Hollowell, C.D., and Schmidt, H.E. (1982) "Trace organic chemical contaminants in office spaces", Environ. Int., 8:129-137.

KEYWORD: VOC, office, solvent, source, energy, exposure, model, control, method, literature, architecture

Workers in offices are exposed to a broad spectrum of organic solvents in very low concentrations relative to promulgated or recommended industrial hygiene exposure levels, but in high concentrations relative to outdoor air. With the aid of simple modeling, working hypotheses about various contaminant sources--new and aged building materials, wet-process photocopies, tobacco smoke, and building maintenance products--are made with respect to their compositions, amount, and emission patterns. Effective control strategies can be implemented that do not compromise energy efficiency.

0155
Miller, Catherine (July 1978) "Exposure assessment modeling: a state-of-the-art review", U.S. EPA, Environmental Research Laboratory, Athens, GA 30605 (56 pages). NTIS PB-286934/LL.

KEYWORD: model,source,exposure, health, risk, literature, EPA$

This review describes current models that simulate the environmental fate of substances, the exposure to such substances, and the effects of such exposure. The focus is first on exposure and effects, where relatively little work has been done, and then on models of environmental fate. Single-medium air and water quality transport models are not assessed, but the possibility of approaching multimedia problems through a combination of single-medium approaches is explored. The report also describes several actual risk assessments made using limited data and considers some secondary applications of the models. More effort has been directed to modeling environmental fate than to modeling exposure and effects, and available models do not cover all of the areas necessary for an exposure assessment.

0672
Miller, S., Mitchell, R., Smithson, G.R. Jr., Price, B., and Hartley, R. (1983) "Acquisition of air pollution data to obtain a 24-hour exposure profile", Frederick, Edward R. et al., Eds., "Proceedings of the specialty conference on measurement and monitoring of noncriteria (toxic) contaminants in air, held in March of 1983 ", Publication no. SP-50, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, pp. 182-195.

KEYWORD: exposure, regulation, monitoring, research, personal, EPA$, methodology, control, vehicle, home, multipollutant

This pilot study is part of a program jointly funded by EPA and the National Institute for Occupational Safety and Health (NIOSH). Heretofore, NIOSH has been more or less limited to the regulation of occupational environments and EPA to ambient environments. For the first time, these two agencies are looking at the overall picture--a 24-hour exposure profile. The study had two main objectives: (1) to acquire and evaluate data to characterize workplace-generated agents and evaluate workplace control devices and practices and (2) to determine if EPA should engage in research to develop technology to control indoor exposure to hazardous air pollutants. This paper describes the methodology employed to acquire and evaluate air pollution exposure data for a segment of the U.S. worker population for the significant environments to which they are exposed in a typical 24-day, including the workplace, in-transit, and the home.

0082
Mitchell, R.I., Smithson, G.R., Jr., and Price, B.P. (Aug. 1984) "A pilot study to obtain 24-hour air pollution exposure profiles", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp.

75-80. NTIS PB85-104214.

KEYWORD: combustion,source, particulate, multipollutant,seasonal, radon, microenvironment, industrial

A pilot study was conducted of workers from a semiconductor plant. This paper describes the methods used to acquire and evaluate air pollution exposure data for significant environments (including workplace, in-transit, and residence) to which workers are exposed throughout a typical day. Summer and winter measurements were made on products of combustion, radon, respirable particulates, and a variety of organic compounds.

0085
Miyazaki, T. (Aug. 1984) "Adsorption characteristics of NOx by several kinds of interior materials", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 103-110. NTIS PB85-104214.

KEYWORD: NOx, NO, NO2, source, humidity, outdoor, model, foreign, laboratory, temperature, Japan

Adsorption characteristics of NOx by several Japanese interior building materials were measured experimentally by the mass balance method. NO2 was adsorbed much more quickly than NO in most materials, especially in flooring materials such as carpet and tatami facings and ceiling materials such as insulation board. On materials where NO2 adsorption was rapid, the velocities were affected by temperature, relative humidity, the degree of stirring speed in the box, and the saturation condition of materials. These adsorption velocities were applied to a theoretical model relating indoor pollutant concentration to outside concentration.

0676
Molhave, L., Lundqvist, G.R., and Anderson, I. (1985) "The atmospheric environment in six energy efficient single family houses", Fanger, P.O., Ed., "Clima 2000, Vol. 4, indoor climate", VVS Kongres -- VVS Messe, Copenhagen, pp. 201-206.

KEYWORD: VOC, energy, pinene, home, foreign,temperature, toluene, ventilation, humidity, solvent, Denmark, architecture

Volatile organic compounds were measured over a year in six new, unoccupied experimental Danish houses with intended low energy consumption. The measurements included air temperature, air humidity, ventilation rate, and concentration of organic gases and vapors. On average, 14 compounds were identified in concentrations exceeding 0.005 mg/m3. Toluene and alpha pinene were most frequently found. For the five periods of measurements, total organic gases and vapors averaged 0.46 mg/m3 (0.032 - 5.5 mg/m3). The concentration decreased systematically during the year, and was on the average halved after 112 days (range of 63 to 187). The concentration of organic gases and vapors of the solvent type was similar to that found earlier in the same houses. Differences in indoor air pollution could not be explained by the materials used for the houses.

0451
Molhave, L., Moller, J., and Andersen, I. (1979) "Air concentrations of gases, vapours and dust in new houses", Ugeskrift for Laeger, 141:956-961. (Danish with English summary.)

KEYWORD: home, field, benzene, VOC, source, particulate, alkane, exposure, foreign, Denmark, children architecture

This study describes measurements taken in Denmark to determine the pollution originating from building materials, furniture, etc., in the children's rooms of 39 occupied apartments built within the past 20 years and in 7 newly built, single-family houses that were ready for occupation.

0169
Molhave, Lars (1982) "Indoor air pollution due to organic gases and vapours of solvents in building materials", Environ. Int., 8(1-6):117-127.

KEYWORD: VOC, solvent, source, model, foreign, Denmark, multipollutant

Emission of organic gases and solvent vapors from 42 commonly used building materials was measured under standard atmospheric conditions. An average of 22 compounds was found in the air around each building material, and the total concentration of gases and vapors was from 0.01 to 1,410 mg/m3. The average arithmetic emission rate was 9.5 mg/m2/hour, and 52 compounds were identified. A mathematical model was established for the indoor air concentrations of pollutants originating from building materials. The model was tested on three model rooms constructed from the materials investigated. The calculated total air concentrations of gases and vapors in the three rooms ranged from 1.6 to 23.6 mg/m3, and the number of compounds in the air from 23 to 32. These concentrations and number of compounds did not differ from those found in actual rooms similar to the model rooms. The risks of health effects due to the compounds identified from the building materials were investigated, and criteria for future air quality standards are discussed.

0596
Molhave, Lars (1985) "Volatile organic compounds as indoor air pollutants", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds. "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 403-414.

KEYWORD: VOC, model, exposure, dose, health, literature, home, field, school,office,industrial,source, foreign, Denmark

This paper reviews the literature of "sick building syndrome" research. Symptoms and exposure data are reviewed for a wide variety of pollutants and building types. In general, exposure to volatile organic compounds concentrations of less than 0.16 mg/m3 cause no mucus membrane irritation; however, exposures to levels greater than 5 mg/m3 do. Reactions to intermediate concentrations can be predicted with a multifactorial model of circumstances, doses, and responses.

0695
Molhave, Lars (1986) "Indoor air quality in relation to sensory irritation due to volatile organic compounds", ASHRAE Trans., Vol. 92, Pt. 1, no. 2954 (10 pages).

KEYWORD: health, VOC, dose,exposure,literature,solvent, emission, industrial, irritant, foreign, Denmark

A subsyndrome to the Sick Building Syndrome (SBS), as defined by a World Health Organization working group, is postulated based on observations in the literature. This subsyndrome relates mucous membrane irritation -- sensory irritation, dryness in nose and eyes, which are very frequent SBS symptoms -- to the total concentration of volatile organic compounds (VOCs) of the solvent type. This VOC syndrome may include other previously unidentified symptoms. The postulated dose-response relation is supposed to be multifactorial, and two thresholds were therefore of interest. Below a lower threshold, no irritation was expected due to VOCs. Total concentrations above the higher limit were expected to cause irritation irrespective of other exposures, which may modify the intensity of the irritation. Concentrations between the two limits may, depending on the effect of other exposures, promote irritation. The few observations reported in the literature indicate these two limits to be about 0.16 mg/m3 and 2 mg/m3. Most of the known total concentrations in the nonindustrial environment are above 0.16 mg/m3. Complaints were reported in all cases where concentrations exceeded 2 mg/m3.

0682
Molhave, L., Bach, B., and Pedersen, O.F. (1986) "Human reactions to low concentrations of volatile organic compounds", Environ. Int., 12(1-4)167-175.

KEYWORD: exposure, VOC, health, odor, statistical, laboratory, foreign, Denmark, irritant

Human subjects were exposed for 2.75 hours to mixtures of 0, 5, and 25 mg/m3 of 22 volatile organic compounds known to be in indoor air pollutants. The exposure occurred in a stainless steel chamber at the Institute of Hygiene, Aarhus, Denmark. The 62 subjects were healthy and without asthma, allergy, or chronic bronchitis but claimed often of dry mucous membranes in eyes, nose, or upper airways. A questionnaire on 26 different air quality aspects revealed significant answers to questions related to general air quality, odor, ability to concentrate, and/or mucous membrane irritation. Continuous evaluation of irritation in eyes, nose, and throat showed significant correlation to exposure at both 5 and 25 mg/m3. The effect was acute, and the subjects showed no signs of adaptation. Their scores on a manual dexterity test decreased during exposure.

0426
Molhave, L., Bisgaard, P., and Dueholm, S. (1983) "A mathematical model of indoor air pollution due to formaldehyde from urea-formaldehyde glued particleboards", Atmos. Environ., 17(10):2105-2108.

KEYWORD: model, CH2O, source, architecture, foreign, Denmark, exposure, methodology, home

A mathematical model of the formaldehyde (CH2O) concentrations in rooms containing particle boards with known emission rates of CH2O is presented. The model is tested in three rooms in a new house. Agreement within +/- 15% is found between calculated and measured CH2O concentrations in the rooms before painting and without furniture, carpets, etc. It is concluded that the combined mathematical model and the analytical method may be suitable for classifying particle boards according to CH2O emissions and for predicting CH2O concentrations indoors.

0105
Monseu, R.M., Sterling, D.A., and Stock, T.H. (Aug. 1984) "The use of field sampling instrumentation for the monitoring of non-industrial environments", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 209-214. NTIS PB85-104214.

KEYWORD: CO, NO2, CH2O, particulate, monitor, personal, exposure, field, QA, home, architecture

A field study, conducted as part of the Texas indoor air quality study of manufactured housing, used portable field instruments to continuously monitor indoor and outdoor formaldehyde, CO, NO2, and suspended respirable particulates. The instruments were required to operate at their optimal sensitivities to detect the typically low concentrations of pollutants encountered in the nonindustrial environment. The instruments proved to be expensive and labor-intensive, requiring daily cleaning and maintenance by highly trained field personnel. Additionally, a rigorous program of quality control and assurance was necessary to achieve and maintain reliability and validity throughout a year-long sampling protocol.

0427
Monteith, D.K., Stock, T.H., and Seifert, W.E., Jr. (1984) "Sources and characterization of organic air contaminants inside manufactured housing", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol 4., chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 285-290.

KEYWORD: VOC, outdoor, home, source, architecture

In recent years, attention has been focused on identifying a broad spectrum of organic vapors in indoor air. This paper discusses 18 frequently seen organic vapors in manufactured housing. Comparison of indoor and outdoor concentrations indicate that generally these 18 contaminants occur at greater concentrations indoors. Building materials (plywood, hardwood plywood panelling, particle board, and carpeting) were tested for organic vapor emissions to investigate contributing sources of indoor air pollutants.

0550
Morgan, M.G, and Morris, S.L. (1977) "Individual air pollution monitors: 2. Examination of some nonoccupational research and regulatory uses and needs", Brookhaven National Laboratory, Upton, NY (17 pages). NTIS BNL-50637.

KEYWORD: personal, exposure, monitor,regulation,research,outdoor, CO, SO2, literature, health, design

Evidence is rapidly growing to show that fixed-station monitors do not provide adequate data for actual population exposure. Available data for CO and SO2 were examined and a new analysis was presented. Actual population exposure to CO appears to be consistently higher than expected when using fixed-station data alone, while limited evidence suggests that exposure to SO2 is lower. A reported general relationship between indoor and outdoor SO2 levels is not supported by the data. If air pollution represents a threat to public health, then more attention must be given to total population exposure to pollutants. Selective use of personal exposure monitors (PEMs), which can be either worn or carried, probably will be required at some stage by any experiment designed to determine the relation between air pollution exposure and health effects. Potential uses of PEMs in air pollution regulation are explored. Current status and research needs for individual air pollution monitors are examined, and a first-order evaluation is given of the promise held by various technologies. A national program of support for the development of individual air pollution monitors is recommended.

0331
Morris, Samuel C. (1981) "Personal monitoring of air pollution exposures", Environ. Int., 5:69-72.

KEYWORD: multipollutant,particulate,literature,personal,exposure, monitor, methodology, epidemiology, regulation

In industrial hygiene and health physics, the goal has been to protect the health of the individual. Therefore, monitoring the exposure people actually receive has been the principal concern. In regulating public exposures to air pollution, the focus has been much different. Recently, use of personal monitors and alternative means of estimating actual exposures has expanded rapidly. This paper discusses the role of personal monitors in epidemiology, exposure studies, and supplementing the existing fixed-station monitoring network for establishing trends for regulatory purposes. The implications for air quality standards in recent findings of personal and indoor exposures are considered. Needed, as well as unneeded, new developments are outlined.

0270
Morse, Salke S., and Moschandreas, Demetrios, J. (March 1979) "Indoor-outdoor pollutant levels: a bibliography", Interim report no. EA-1025, Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, CA 94304 (169 pages).

KEYWORD: multipollutant, literature, source, health, home, office

This annotated bibliography covers literature on indoor and outdoor pollution levels. Specifically, the works cited are those which have a bearing on the study, "Comparison of Indoor and Outdoor Concentrations of Atmospheric Pollutants," which is being supported by the Electric Power Research Institute (EPRI) and conducted by Geomet, Inc. of Gaithersburg, MD. The bibliography primarily contains available publications and research reports that are relevant to the specific objectives of the EPRI-Geomet project: indoor sources of pollutants, behavior of indoor pollutants, indoor-outdoor relationships, and health effects. It does not cover construction or conservation measures that affect indoor pollutant concentrations. The bibliography focuses on residences and offices.

0516
Moschandreas, D.J., et al. (1981) "Radon and aldehyde concentrations in the indoor environment", U.S. Department of Energy, Office of Buildings and Community Systems, Washington, DC 20585 (30 pages). NTIS LBL-12590.

KEYWORD: CH2O, radon, ventilation, energy, ventilation, home, exposure, control

Formaldehyde and radon were measured in an energy-efficient residence in Mt. Airy, MD. Air quality samples (specifically Rn and aldehydes) were collected and analyzed. Relationships between air infiltration rates and contaminant levels were developed. At low infiltration rates, radon and formaldehyde concentrations were above levels recommended to protect health. Increasing the mechanical ventilation reduced those levels to within the recommended range.

0706
Moschandreas, D.J., Winchester, J.W., Nelson, J.W., and Burton, R.M. (1979) "Fine particle residential indoor air pollution", Atmos. Environ., 13:1413-1418.

KEYWORD: monitoring,energy,particulate, home,ventilation, model, outdoor, Pb, Br, K, Fe, S

Indoor-generated elemental constituents of fine aerosol particulate matter may be distinguished from constituents infiltrating from the outdoors by comparing time variation in concentrations on an hourly basis. Measurements within three residential buildings indicate that S and Pb-Br aerosols are predominantly of outdoor origin, although a secondary indoor Pb source was detected. K is, to a significant degree, of indoor origin. Indoor-outdoor exchange times inferred for fine particle constituents agree with those estimated for gas exchange and with model calculations, suggesting conservative fine aerosol transport, i.e., no sources or sinks. However, coarse particle constituents, e.g., Fe, vary with time, complicated by nonconservative behavior such as removal by filtration and settling. The experimental techniques used--time sequence filter sampling of aerosols and elemental analysis by proton-induced x-ray emission--are generally applicable to studies of the indoor working and living microenvironments.

0502
Moschandreas, D.J., Zabransky, J., and Pelton, D.J. (1981) "Comparison of indoor and outdoor air quality (final report)", Electric Power Research Institute, 3412 Hillview Ave., Palo Alto, CA 94304 (230 pages). NTIS EPRIEA-1733.

KEYWORD: outdoor,CO,NOx,SO2,particulate,field, exposure, smoking, monitor,source,home,CO2,seasonal,appliance,model,office

Data are presented from a 24-month comprehensive study of the air quality in indoor nonindustrial environments. The research program includes a 9-month field study in the Boston, MA, metropolitan area designed to monitor and compare the indoor and outdoor air quality at 10 residences and 2 office buildings using a mobile monitoring unit. Seasonal variations were investigated by monitoring 2 of the 10 residences twice. Residences under real-life conditions for 2 weeks and offices were monitored for 3 weeks. Air samples were obtained from three indoor locations and at one outdoor site, adjacent to the building monitored. Residences were classified as either having gas facilities or electric facilities. In general, concentrations of CO, NO, and NO2 in residences with gas facilities are greater than corresponding outdoor levels while the concentrations in residences with electric facilities are similar to outdoor levels. Indoor office concentrations of CO, NO, and NO2 typically coincide with outdoor levels. Concentrations of total suspended particulates (TSP) at the office buildings are equal to or slightly below outdoor levels. A study of indoor zones indicates that hourly pollutant concentrations obtained from one indoor location are sufficient to characterize indoor air quality. However, measurements from one indoor location are not adequate to specify indoor pollution concentration maxima in residences with indoor sources. The GEOMET Indoor-Outdoor Air Pollution model was validated using the data base for long-term (24-hour) periods.

0162
Moschandreas, D.J., and Rector, H.E. (1982) "Indoor radon concentrations", Environ. Int., 8:77-82.

KEYWORD: radon, field, home, outdoor, architecture, ventilation, methodology

The indoor air of 60 residences in and around a Maryland suburb of Washington, DC, was monitored in a pilot study to determine radon concentrations. In each residence, a radon grab sample was taken in the living room and, if possible, in the basement. Infiltration rates were determined by tracer gas dilution. To help standardize sampling conditions, each home remained closed for 8 hours prior to sampling and during analysis. More than 60% of the residences sampled showed air infiltration rates of fewer than 0.6 air changes per hour. Approximately 55% of all surveyed basements and 30% of all surveyed living areas displayed radon concentrations in excess of 4.0 nanocuries/m3. Assuming an equilibrium factor of 0.5, these radon levels may lead to working levels above the annual guidelines suggested by EPA for Florida homes built on land reclaimed from phosphate mining.

0175
Moschandreas, D.J., and Zabransky, J., Jr. (1982) "Spatial variation of carbon monoxide and oxides of nitrogen concentrations inside residences", Environ. Int., 8:177-183.

KEYWORD: CO, NO, NO2, monitoring, home, statistical, appliance, field, office

Pollutant concentrations were compared in three indoor sampling locations (zones) inside residences. The indoor air quality base was obtained from sampling 12 homes and two office buildings in the Boston, MA, area. Each home was monitored continuously for 2 weeks, and data were reduced into hourly averages. Interzonal comparisons of the mean of hourly averages, 24-hour averages, and daily maximum hourly concentrations were made at all sites. Linear regressions were computed between daily maximum hourly concentrations and mean 24-hour concentrations of NO, NO2, and CO for kitchens to determine whether maximum hourly concentrations could be predicted from the 24-hour concentration. These pollutants showed interzonal statistical differences in residences with gas-fired cooking facilities but not in residences with electric cooking facilities. Maximum indoor hourly concentrations for NO, NO2, and CO can be estimated for residences with all-electric facilities, by using the mean 24-hour concentration. Similar estimates for NO, NO2, and CO in residences with unvented gas appliances are less reliable because of more scatter of the paired data points, particularly at higher pollutant concentrations.

0756
Moschandreas, D.J., and Rector, H.E. (1981) "Radon and aldehyde concentrations in the indoor environment", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (29

pages). NTIS LBL-12590.

KEYWORD: CH2O, radon, home, energy, monitor,aldehyde,ventilation, health, temperature, humidity, control, exposure

This report summarizes findings regarding indoor contaminants in an energy-efficient residence in Mt. Airy, MD. The objectives of this study were to (1) collect relevant air quality samples (specifically radon and aldehydes), (2) analyze aldehyde samples, and (3) characterize radon and aldehyde levels and develop relationships between air infiltration rates and contaminant levels. Total aldehydes were collected with impingers filled with MBTH (3-methyl-2-benzothiazoline hydrazone hydrochloride). Formaldehyde (CH2O) was sampled with impingers filled with distilled water. One fifth of the measured CH2O concentrations were in the range that may cause health concerns. Although indoor temperature and humidity affect indoor CH2O concentrations, the elevated concentrations were measured under very low air infiltration rates. The data show that ventilation is somewhat effective in reducing high CH2O levels. Three methods were used to measure radon from August 1979 through April 1980: (1) week-long integrated values using thermoluminescent chip assemblies, (2) grab samples collected by pumping air into Tedlar bags, and (3) the Continuous Radon Monitor developed by Lawrence Berkeley Laboratory. A considerable number of the collected samples had radon concentrations higher than 1.0 - 4.0 nanoCurie/m3. Assuming an equilibrium factor of 0.5, these levels would correspond to working levels above the health guidelines suggested by the U.S. EPA for homes in Florida built on land reclaimed from phosphate mining. As with CH2O, increased ventilation reduced radon levels.

0235
Moschandreas, Demetrios J., et al. (1980) "The effects of woodburning on the indoor residential air quality", Environ. Int., 4(5-6):463-468.

KEYWORD: wood, office, outdoor, monitoring, particulate, home, benzo-a-pyrene, combustion, source

The increase in residential wood stove use led to an assessment of the effects on indoor air quality. The indoor and outdoor air pollution of ten residences and two office buildings were compared; three of these residences used either a wood stove or a fireplace. Monitoring for 2 weeks at each residence under real-life conditions indicated that indoor total suspended particulate (TSP) concentrations during wood burning were about 300% of corresponding levels during nonwood burning periods. Elevated indoor concentrations of TSP, respirable particulates, and benzo-a-pyrene were attributed to wood burning.

0660
Moschandreas, Demetrios J. (1981) "Exposure to pollutants and daily time budgets of people", Bull. N.Y. Acad. Med., 57(10):845-859.

KEYWORD: multipollutant,microenvironment,exposure,personal,model, activity,health,statistical,monitoring,indoor,outdoor,research

Exposure is a measure of pollutant concentration available at the exchange boundaries of a receptor during specified times. These concentrations vary greatly in the places, or microenvironments, where people spend time each day. The time budgets of people and the pollutant concentrations in each microenvironment are the essential data to calculate a person's actual exposure to an air pollutant. Because most people spend up to 90% of their time indoors, outdoor stationary monitoring networks cannot provide adequate data to assess an individual's total exposure. As building ventilation has declined in recent years because of energy conservation, indoor pollutant concentrations and concomitant health complaints have increased. Instrumentation, experimental designs, and mathematical models for assessing indoor and total exposures are developing rapidly.

0740
Moschandreas, Demetrios J. (1983) "Emission factors of volatile organic compounds and other air constituents from unvented gas appliances", Frederick, Edward R., et al., Eds., "Proceedings of the specialty conference on measurement and monitoring of noncriteria (toxic) contaminants in air, held in March of 1983 ", Publication SP-50, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, pp. 425-434.

KEYWORD: source, combustion, VOC, CH2O, appliance, model, PAH, monitoring

Research on indoor air quality has focused on the spatial and temporal distribution of criteria pollutants. To fully characterize the indoor environment, this study has started to investigate emission factors of all air constituents by modeling a large number of complex indoor conditions. Emission factors from the top burner of three unvented gas ranges have been used to measure volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), including nitro-PAH, and formaldehyde. Air samples for VOCs were obtained using Tenax samplers and analyzed by gas chromatography/mass spectrometry. Specifically designed impingers were used to sample PAHs, which were analyzed by high-pressure liquid chromatography. The pararosaniline analysis technique was used to measure formaldehyde. In addition to these gas-phase constitutents, particulate matter was measured using both gravimetric and aerosol active scattering spectrometer techniques. Early results indicate low emission factors for the air constituents studied.

0485
Moschandreas, D.J., Stark, J.W.C., McFadden, J.E., and Morse, S.S., (Dec. 1978) "Indoor air pollution in the residential environment: volume 1. data collection, analysis and interpretation" U.S. EPA, Environmental Research Center, and U.S. Department of Housing and Urban Development, Office of Policy and Developement Research (182 pages). NTIS PB-290999.

KEYWORD: multipollutant, microenvironment, home, energy, health, model, field, outdoor, source, methodology

A 24-month study was undertaken to characterize indoor air quality in 17 residences. Air samples were collected for 14 days from four locations: one outdoor site adjacent to the building and three indoor sites (kitchen, bedroom, and living room). "Continuous" sampling was carried out for CO, SO_2, NO, NO_2, CO_2, O_3, methane, and total hydrocarbons. Total suspended particulates, respirable suspended particulates, SO_4, NO_3, Pb, ammonia, and aldehydes were monitored intermittently. Aerosol samples were collected for elemental analysis by proton-induced x-ray emission (PIXE). In addition, data on energy parameters, infiltration rates, and family activities were obtained by observations, field experiments, and daily questionnaires, respectively. Two numerical models formulated in the study are discussed in this document. The GEOMET Indoor Outdoor Air Pollution (GIOAP) model simulates indoor conditions and estimates indoor gaseous pollutant concentrations as a function of outdoor levels, air exchange rates, indoor source strengths, and pollutant decay rates. The second model, the Steady State TSP model, is an empirical model that estimates indoor TSP levels as a function of outdoor levels, air exchange rates, removal mechanisms, and indoor TSP source terms. The relationship between energy conservation measures and air quality in the indoor environment is also examined. In addition, a number of scenarios that conserve energy in residences but do not affect air quality are discussed.

0637
Moschandreas, Demetrios J. (1981) "A survey study of residential radon levels", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (30 pages). Not available from NTIS.

KEYWORD: radon, sampling, design, methodology, exposure, home, research

A pilot survey in a Maryland suburb of Washington, DC, sampled many indoor environments rather than making a few detailed investigations. The primary goals were to (1) design and assess a survey methodology for sampling the indoor air of many residences and (2) determine if an experimental house with high radon levels is a local anomaly or representative of the surrounding neighborhood or area. More work is needed in techniques for recruiting participants than in sampling or data interperetation. Radon concentrations declined with distance from the experimental house.

0149
Moses, David O. (Jan. 1986) "Indoor air quality environmental information handbook: radon", U.S. Department of Energy, Office of Environmental Analysis, Washington, DC 20585 (210 pages). NTIS DE86-005006/LL.

KEYWORD: radon, literature,health, home, risk, water, control

This handbook summarizes available information that may assist technical and nontechnical readers to understand what is now known about indoor radon. The handbook is divided into sections that cover sources and transport mechanisms, factors influencing indoor concentrations, health effects, models, controls, and homeowner considerations.

0611
Mulik, James D., and Williams, Dennis (1986) "Passive sampling devices for NO2", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 61-70. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: methodology, NO2, sampling, personal, exposure, monitor, EPA$

For the past several years, considerable progress has been made in the development of passive sampling devices for collecting and analyzing both inorganic and organic air pollutants. This paper describes the status of EPA's program in developing a passive sampling device for the collection and analysis of NO2 for indoor air applications. Analytic and logistic characteristics of several techniques are discussed.

0153
Munn, R.E., Spengler, J., Waller, R., and deKonig, H.W. (1982) "Estimating human exposure to air pollutants", Offset publication no. 69, World Health Organization, Geneva, Switzerland (59 pages).

KEYWORD: literature, outdoor, multipollutant, personal, exposure, monitor, methodology, ventilation, model

The present state of air pollution exposure monitoring is reviewed. Several aspects of outdoor air quality are discussed, including ambient air quality networks, temporal and spatial variations in ambient air quality, and the use of ambient air quality data in exposure assessments. Some of the shortcomings of ambient air quality data are (1) the data were not collected for health-related purposes, (2) only a few pollutants are usually measured, and (3) the data do not represent actual human exposures. Reasons for studying indoor air are given, including the occurrence of pollution from stoves, cigarettes, and building materials, the effect of ventilation systems such as air conditioning, and the effect of natural ventilation of buildings. SO_2, CO, NO_x, formaldehyde, and suspended particulates are discussed in detail, while radon, asbestos, mineral and synthetic fibers, and O_3 are discussed briefly. Other subjects covered include socioeconomic factors affecting exposure, such as occupation and lifestyle; personal exposure monitors for specific pollutants; and exposure models that take into account ambient air quality, neighborhood air quality, indoor-outdoor air pollution relationships, and population activity patterns.

0414
Muramatsu, M., Umemura, S., Okada, T., and Tomita, H. (1984) "Estimation of personal exposure to tobacco smoke with a newly developed nicotine personal monitor", Environ. Res., 35:218-227.

KEYWORD: nicotine, home, smoking, personal, exposure, monitor, methodology, foreign, Japan

To evaluate the actual level of exposure of nonsmokers to tobacco smoke in their living environments, a convenient personal monitor of nicotine specific for tobacco smoke has been developed. The nicotine personal monitor consists of a sampler tube containing 450 mg of Uniport-S coated with silicon OV-17 and a portable sampling pump with a mechanical counter for obtaining total sampling volume. Using the personal monitor attached to a nonsmoker, ambient nicotine was collected in the sampler tube by drawing environmental air at a constant flow rate for a maximum 8 hours. The collected nicotine was desorbed by heating and directly transferred onto a gas chromatograph column. The amounts of nicotine inhaled by passive smoking in various living environments were estimated to range from 0.9 to 40 micrograms per hour. These levels are equivalent to those from the active smoking of about 0.001 to 0.044 ordinary cigarettes in 1 hour.

0346
Muramatsu, Satoru (1984) "Indoor air pollution in Japanese buildings", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 443-449. NTIS PB85-104222.

KEYWORD: CO, CO2, particulate, temperature, humidity,ventilation, regulation, exposure, field, foreign, Japan

Under the provisions of the Law for Maintenance of Sanitation in Buildings, the "Building Sanitation Control Standards" came into force in Japan. The air-quality portion of these standards is composed of suspended particles, CO2, CO, temperature, relative humidity, and air velocity. Since the enactment of the law, actual conditions of indoor environment have been surveyed for 13 years, and the percentage of buildings that failed to come up to the standards was found.

0548
Murphy, M.J., Stickford, G.H., Locklin, D.W., and Wensky, Afaf K. (1986) "A technique to survey indoor halocarbon levels using flame-oxidation and condensate analysis", Paper no. 86-37.2, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (15 pages).

KEYWORD: halocarbon, sampling, economic, methodology, QA, VOC, laboratory, design

Analyzing indoor air for individual halocarbon species is tedious and costly. In most air-quality surveys, total halocarbon analysis can be used to flag sites that require further investigation. A method for analyzing air samples for total halocarbons at the ppb-level is described. The flame-oxidation condensate technique is based on analysis of the condensate obtained by cooling the combustion products of a flame supported by pure methane and the air to be sampled. Halocarbons are oxidized in the flame to form hydrogen halides, which dissolve in the condensate formed when the combustion products cool. Once the halide has been absorbed in the condensate, the halide concentration of the resulting aqueous solution can be determined by ion chromatography. Flame-oxidation condensate analysis can detect as little as 5 ppb of halocarbons in air with an accuracy of +/- 20%.

0477
Myronuk, D.J. (1977) "Augmented ingestion of carbon monoxide and sulfur oxides by occupants of vehicles while idling in drive-up facility lines", Water, Air Soil Pollut., 7:203-213.

KEYWORD. SOx, vehicle, interior, literature, exposure, weather, CO, temperature, field, outdoor, ventilation, health

A line of automobiles waiting at a drive-up facility generally expels idling engine emissions rearward. These emissions tend to envelope the vehicles at the end of the line. Factors affecting these highly localized pollutant-accumulation episodes include local meteorological conditions (low altitude inversions, winds, and temperatures); number, age, and tune-up condition of the cars; exhaust pipe location; interior air-handling equipment; vehicle separation distances; and natural or artificial barriers that form troughs or partial enclosures in which vehicular emissions can accumulate or be trapped. In this study, CO concentrations were measured in a series of typical vehicle line-ups. In Santa Clara Valley, CA, the 15-minute average driver-area concentration levels ranged from 15 ppm to 95 ppm, with short-term peaks between 100 and 1,000 ppm; background levels are 2 to 5 ppm. Wide variations in concentrations can be expected if ventilating fans for heater or air conditioner units are also operating. Using the CO levels as indicators of the accumulation of local automobile-produced pollutants (when a majority of cars are equipped with catalytic converters), the anticipated adverse effects of SOx concentrations, irritation and inflammation of healthy lung tissue, as well as aggravation of preexisting lung or heart conditions, will be the most undesirable features of drive-up facility services. Potential reductions in the extent of this developing problem include S removal, SOx traps, and exhaust system redesign.

0226
Nagda, Niren L., and Koontz, Michael D. (1985) "Microenvironmental and total personal exposures to CO for three population subgroups", J. Air Pollut. Control Assoc., 35(2):134-137.

KEYWORD: CO, office, smoking, source, microenvironment, personal, exposure,monitor,activity,demographic,combustion,appliance

This study measured personal exposure to CO of domestic, construction, and office workers in the Washington, DC, area during the fall of 1982. Participants carried personal CO monitors and activity diary cards for 24-hour periods. Participant selection methods, monitoring device characteristics, and data quality are described. Data are tabulated by microenvironment, person type, building use, appliance types, and presence of smokers. Data tables include comparisons with the EPA study that followed in the winter.

0350
Nagda, N.L., and Rector, H.E. (1984) "Important design consideratons for residential indoor air quality studies", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 517-522. NTIS PB85-104222.

KEYWORD: literature, methodology, sample, design, home

With recent advances in technology, choices among measurement strategies for indoor air quality investigations have become increasingly complex. Design must weigh objectives and available technology against resources to implement the design. This paper provides a systematic framework for making proper choices among critical design alternatives. Design considerations include types of instrumentation, location of probes, and number and frequency of measurements. Examples drawn from case studies illustrate these considerations.

0630
Nagda, Niren L., Rector, Harry E., and Koontz, Michael D. (1987) "Guidelines for monitoring indoor air quality", Hemisphere Publishing Corp., New York, NY 10016 (275 pages).

KEYWORD: methodology,design,exposure,QA,EPA$,personal,monitoring, sampling,model,statistical,multipollutant,literature,research

This book provides direct and systematic guidance on monitoring indoor air pollution. It reviews the history and future research needs of the entire field and work on many individual pollutants. Other subjects reviewed are (1) factors affecting indoor air pollution concentrations, such as sources, ventilation, and reactivity; (2) mathematical modeling of indoor air pollutant behavior; (3) experimental methodology and design problems; (4) U.S. EPA data quality assurance procedures; and (5) bibliographic and organizational sources of information. Appendices provide specifications of commercially available and user-configured monitoring equipment.

0223
Nagda, Niren, and Rector, Harry (1983) "Guidelines for monitoring indoor air quality", U.S. EPA, Office of Research and Development, Washington, DC 20460, (246 pages). NTIS PB83-

264465.

KEYWORD: methodology, EPA$, QA, sample, design, model, source, architecture

This document provides guidelines for designing programs to measure indoor air quality and associated factors. Brief summaries of past and current research and descriptions of indoor contaminants provide a background for developing the monitoring design. Factors that influence indoor air quality are discussed with the aid of mass balance models. An extensive review of measurement systems, including a listing of numerous instruments with their performance specifications, is presented. Design considerations are discussed for two types of studies--applied research in indoor air quality and investigations of building-associated problems. A systematic approach for developing the design is also described. In addition, the document presents a format for data reporting and suggestions on quality assurance and quality control.

0236
Nasralla, M.M. (1980) "Studies on indoor air quality in Egypt," Environ. Int., 4(5-6):469-473.

KEYWORD: particulate, CO, SO2, source, weather, Pb, combustion, outdoor,foreign, Egypt

Indoor levels of some gaseous and particulate pollutants were examined. In a public library, the indoor/outdoor ratio of gaseous pollutants was found to be dependent on their reactivity, outdoor concentrations, and weather conditions. This ratio was 0.6 for SO2 and 1.3 for CO. The indoor/outdoor ratio of CO was found to increase at the higher floors of the same building. Concentrations of indoor particulates were influenced by the outdoor concentrations and the particle size. Indoor suspended dust contained significantly more Pb than outdoor dust. Indoor sources polluted fossil-fuel-burning homes, thus causing CO concentrations greater than the recognized threshold limit value for industry.

0667
National Academy of Sciences (1986) "Environmental tobacco smoke - measuring exposures and assessing health effects", National Academy Press, 2101 Constitution Avenue, N.W., Washington, DC 20418 (337 pages).

KEYWORD: smoking,literature,health,field,model,personal,exposure, monitoring,sampling,biomonitoring,methodology,QA,risk,dose

With a focus on methodology, this report (1) reviews the chemical and physical characterizations of environmental tobacco smoke (ETS), (2) includes a toxicological profile of sidestream and environmental tobacco smoke, (3) reviews the epidemiologic and related literature on the health effects of exposure to ETS, and (4) recommends future exposure monitoring, modeling, and epidemiologic research. The primary goal of the studies reviewed was to determine possible relationships between ETS exposure and health effects in nonsmokers.

0768
National Council on Radiation Protection and Measurements (NCRP) (March 1984) "Exposures from the uranium series with emphasis on radon and its daughters", NCRP report no. 77, NCRP, 7910 Woodmont Avenue, Bethesda, MD 20814 (132 pages).

KEYWORD: radon,radiation,dose,research,exposure, regulation,risk, outdoor,source,home,water,lung,foreign,Sweden,Canada,control

The National Council on Radiation Protection and Measurements surveyed the sources of radon, levels of exposure, their probable distribution, and the associated risks. The report summarizes characteristics of the uranium series, soil content and transport, external radiation, human intake pathways and dose (inhalation, drinking water, ingestion), and the council's recommendations. Radon daughter exposure potentially constitutes the most significant exposure to the U.S. population. Radon inhalation is likely the most significant exposure factor, while external exposure and ingestion of radionuclides are less significant; the relative importance of these exposure classes, however, varies with location or occupation. The council recommends remedial action if an individual's total exposure to radon daughters exceeds an annual average of 2 working levels (WL)/month, including background, which is defined as the remedial action level for inhalation. The recommended remedial action level for penetrating external radiation from all sources, excluding medical, is 500 WL/year. Because ingestion contributes little to exposure, no recommendation is made. The report discusses regulatory action in the U.S., Canada, and Sweden. The council recommends a preliminary survey of 1,000 homes to determine the need for a larger program in the U.S.

0022
National Academy of Sciences (1981) "Indoor pollutants", National Academy Press, 2101 Constitution Ave., NW, Washington, DC 20418 (560 pages).

KEYWORD: multipollutant, monitor, model,health, exposure,control, ventilation,EPA$,personal,regulation,source,research,literature

This report characterizes the quality of the indoor environment--primarily with respect to airborne pollutants, although others are discussed--and the potential adverse health effects of indoor pollutants. The report is a review of the available knowledge and an assessment of research needs. In this report, "indoor" refers to common indoor spaces to which the public has access. However, industrial working environments are excluded. The report does not include all the pollutants found indoors that are hazardous to human health, but instead provides a variety of examples intended to describe the sources, pathways of exposure, and other dynamics of indoor pollution.

0462
Nazaroff, W.W., et al. (1985) "Radon transport into a detached one-story house with a basement", Atmos. Environ., 19(1):31-46.

KEYWORD: radon, source, ventilation, weather, exposure, field, indoor, model, home, water, statistical, research

During a 5-month study, radon concentration and source parameters, ventilation rate, and weather were continuously monitored in a house near Chicago, IL. The results suggest that the basement sump and perimeter drain-tile system played an important role in influencing the radon entry rate and that pressure-driven flow was more important than diffusion as a mechanism for radon entry. Fireplace operation substantially increased the air-exchange rate, but had only a small effect on indoor radon concentration, corroborating that pressure-driven flow is an important mechanism for radon entry into this house.

0257
Nazaroff, W.W., and Nero, A.V. (Feb. 1984) "Transport of radon from soil into residences", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (15 pages). NTIS DE84-015996/XAB. Also in Atmos. Environ., 19(1):31-46.

KEYWORD: radon, home, monitoring, source, architecture

Developing effective monitoring and control programs for indoor radon requires understanding of the causes of the broad range of concentrations that have been observed. Measurements of indoor radon concentration and air-exchange rate in dwellings in several countries indicate that this variability arises largely from differences among structures in the rate of radon entry. Recent evidence further suggests that (1) a major source of indoor radon in many circumstances is the soil adjacent to the building foundation and that (2) pressure-driven flow, rather than molecular diffusion, is the dominant transport process by which radon enters the buildings. Key factors affecting radon transport from soil are radon production in soil, flow-induction mechanisms, soil permeability, and building substructure type.

0447
Nazaroff, William W., and Case, Glen R. (1986) "Mathematical modeling of chemically reactive pollutants in indoor air", Environ. Sci. Technol., 20(4):924-934.

KEYWORD: NO, NOx, NO2, NO3, model, exposure, olefin, O3, HNO2, ventilation, N2O5, source, hydrocarbon, architecture

A general mathematical model is presented for predicting the concentrations of chemically reactive compounds in indoor air. The model accounts for the effects of ventilation, filtration, heterogeneous removal, direct emission, and photolytic and thermal chemical reactions. The model is applied to the induction of photochemically reactive pollutants into a museum gallery, and the predicted NO, NOx-NO, and O3 concentrations are compared to measured data. The model predicts substantial production of several species due to chemical reaction, including nitrous acid, nitric acid, and N2O5. Circumstances in which homogeneous chemistry may assume particular importance are identified and include buildings with glass walls, indoor combustion sources, and direct emission of olefins.

0510
Nazaroff, W.W., Boegel, M.L., and Nero, A.V. (1981) "Measuring radon source magnitude in residential buildings", U.S. Department of Energy, Office of Buildings and Community Systems, Washington, DC 20585 (33 pages). NTIS DE82-000774.

KEYWORD: radon, ventilation, source, sampling, model, exposure, home, field, statistical, distribution

The procedures are described for use in residences for simultaneously taking rapid "grab sample" and time-dependent measurements of the air exchange rate and radon concentration. The size of the radon source is calculated from the two measurements. Grab-sample measurements in three survey groups comprising 101 U.S. houses showed that the source varied approximately log-normally with a geometric mean of 0.37 and a range of 0.01 to 6.0 picoCuries per liter-hour. Successive measurements in six houses in the northeastern U.S. showed considerable variability in source size within a given house. In two of these houses, the source magnitude showed a strong correlation with the air-exchange rate, suggesting that soil gas influx can be an important transport process for indoor radon.

0703
Nazaroff, W.W., Boegel, M.L., Hollowell, C.D., and Roseme, G.D. (1981) "The use of mechanical ventilation with heat recovery for controlling radon and radon-daughter concentrations in houses", Atmos. Environ., 15:263-270.

KEYWORD: energy, radon, ventilation,monitor, laboratory, control, home

An energy research house in Maryland had radon concentrations far in excess of recommended guidelines. A mechanical ventilation system with heat recovery was installed in this house to test its effectiveness as an energy-efficient technique to control indoor radon. Radon concentration was monitored continuously for 2 weeks under varying ventilation conditions [0.07-0.8 air changes per hour (ach)], and radon-daughter concentrations were measured by grab-sample techniques about nine times daily during this period. At ventilation rates of 0.6 ach and higher, radon-daughter levels dropped below guidelines for indoor concentrations. Other studies indicate that indoor radon buildup may be a problem in a considerable portion of houses having low infiltration rates. Mechanical ventilation systems with air-to-air heat exchangers may offer a practical, cost-effective, and energy-efficient means of alleviating not only the radon problem specifically but also the general deterioration of indoor air quality in many houses designed or retrofitted to reduce infiltration.

0444
Nelms, L.H., Reiszner, K.D., and West, P.W. (1977) "Personal vinyl chloride monitoring device with permeation technique for sampling", Anal. Chem., 49:994-998.

KEYWORD: vinylchloride, personal, exposure, monitor, sampling, humidity, temperature, laboratory, QA, OSHA

A method for measuring personal exposure to vinyl chloride has been developed that uses the permeation technique for sampling. The vinyl chloride that permeates the membrane is trapped on activated charcoal, which is removed for subsequent determination by gas chromatography. The monitor is about the size of a standard film badge, weighs less than 35 g, and requires no source of power. The method is insensitive to temperature and humidity, and is free of significant interferences. The method is ideally suited to personal monitoring programs required by Occupational Safety and Health Administration (OSHA) regulations, because the analytical data represent a time-weighted average exposure and require no further data reduction.

0508
Nero, A.V., Boegel, M.L., Hollowell, C.D., Ingersol, J.G., Nazaroff, W.W., and Revzan, K.L. (1980) "Radon and its daughters in energy-efficient buildings", U.S. Department of Energy, Office of Energy Research, Washington, DC 20585 (8 pages). NTIS DE82-020291.

KEYWORD: radon, methodology, QA, control, architecture, energy, source, home, field, exposure

Radon emanation rates and radionuclide concentrations have been measured in building materials and radon and daughter concentrations surveyed in residences. Control techniques and strategies are being examined, and significant effort has been devoted to developing instrumentation. To characterize radon and its daughters indoors more completely, more substantial efforts are needed on geologic distribution of radon, transport into structures, daughter behavior indoors, and instrument response under various conditions.

0470
Nero, A.V., Boegel, M.L., Hollowell, C.D., Ingersoll, J.G., and Nazaroff, W.W. (1983) "Radon concentrations and infiltration rates measured in conventional and energy-efficient houses", Health Phys., 45(2):401-405.

KEYWORD: radon, monitoring, energy, sampling, field, indoor,home, ventilation, exposure

The authors have concurrently measured the radon-222 concentration and the infiltration rate in U.S. houses. Three housing surveys were undertaken: one in "energy-efficient" houses located throughout the United States and two in "conventional" houses in the San Francisco, CA, area and in Maryland. In each group surveyed, no clear correlation was observed between radon-222 concentrations and infiltration rate, although each parameter varied over a wide range. Infiltration rates for the entire sample (98 houses) ranged between 0.02 and 1.6 air changes per hour, and radon-222 concentrations ranged from 0.1 to 27 picoCuries per liter. It appears that the major cause of the observed differences in radon-222 concentration is variation from one house to another in the rate at which radon-222 enters the houses.

0679
Nero, A.V., and Lowder, M.M., Eds. (1983) "Special issue of Health Phys.", Health Phys., 45(2):273-574.

KEYWORD: radon, dose, source, exposure, personal, distribution, methodology, radiation

The special issue was devoted to radon in the indoor environment, its sources and transport properties, production and behavior of its radioactive decay daughters, and the population radiation exposure resulting from inhalation of the daughters. In addition, several papers concerned measurement techniques and applications.

0507
Nero, Anthony V. (1983) "Radon in energy-efficient earth-sheltered structures", U.S. Department of Energy, Office of Energy Research, Washington, DC 20585 (6 pages). NTIS DE83-015992.

KEYWORD: radon, energy, health, home, risk,ventilation, exposure, literature, industrial, source, architecture, control

Exposure to Rn-222 in indoor air constitutes the most significant radiation dose received by the general population in most countries. Indoor concentrations amomg buildings range from insignificant levels to very high levels that cause radiation doses higher than those received by uranium miners. This wide range of concentrations is attributable to (1) variability in the rate at which Rn enters buildings, from whatever source, and (2) differences in ventilation rates, which determine the Rn concentration in indoor air. In single-family dwellings, the major source of Rn is the ground underlying the structure. The strength of this source varies with both the soil concentrations of Rn -226 (from which Rn-222 arises) and the type of structure. Earth-sheltered dwellings, because they are more completely surrounded by earth material than other structures, have a potential for higer Rn levels higher than other houses in the same region. In addition, energy-saving measures that reduce ventilation rates can also raise indoor Rn concentrations. For these reasons, a significant effort is needed to determine the potential for high indoor Rn levels resulting from ventilation-reducing measures and earth sheltering, especially in regions where Rn levels are already high. Attention should be given to specific design features that affect indoor Rn concentrations.

0645
Nero, A.V., Schwehr, M.B., Nazaroff, W.W., and Revzan, K.L. (1986) "Distribution of airborne radon-222 concentrations in U.S. homes", Science, 234:992-997.

KEYWORD: statistical, literature,seasonal, radon, dose, QA, risk, health, home, distribution, monitoring, lung

Apparently large exposures of the general public to radon-222 decay products in indoor air have led to systematic appraisal of monitoring data from U.S. single-family homes; several ways of aggregating data were used that take into account differences in sample selection and season of measurements. The resulting distribution of annual-average radon-222 concentrations can be characterized by an arithmetic mean of 1.5 picoCuries per liter (pC/L) and a long tail with 1 to 3% of homes exceeding 8 pC/L, or by a geometric mean of 0.9 pC/L and a geometric standard deviation about 2.8. The standard deviation in the means is 15%, estimated from the number and variability of the available data sets. The total uncertainty is larger, however, because these data may not be representative. Available dose-response data suggest that (1) an average of 1.5 pC/L contributes about 0.3% lifetime risk of lung cancer and (2) in the million homes with the highest concentrations, where annual exposures approximate or exceed those received by underground uranium miners, long-term occupants suffer an added lifetime risk of at least 2%, reaching extraordinary values at the highest concentrations observed.

0509
Nero, A.V., Berk, J.V., Boegel, M.L., Hollowell, C.D., Ingersoll, J.G., and Nazaroff, W.W. (1981) "Radon daughter exposures in energy-efficient buildings", U.S. Department of Energy, Office of Energy Research, Washington, DC 20585 (9 pages). NTIS DE82-003711.

KEYWORD: radon, energy,health, lung,risk,ventilation, literature, home, exposure, industrial, control, source, architecture

A radon concentration of 1 picoCuries/Liter (pCi/L) (37 Becquerels/cubic meter) appears to be typical for air inside U.S. residences. However, some residences have higher concentrations, sometimes by an order of magnitude, which implies significant individual risk to occupants. For typical radon daughter equilibrium ratios, this concentration corresponds to a radon daughter exposure rate of 0.2 working level months (WLM) per year. This exposure rate may account for a significant lung cancer incidence if data on lung cancers per unit exposure in miners are applicable to such low exposures. Reducing air exchange rates may raise the typical exposure rate and in some case even increase it to unacceptable levels. Measures that reduce energy use by reducing natural infiltration or mechanical ventilation in new or retrofit buildings are therefore undergoing severe scrutiny. In many buildings specifically designed to use energy efficiently or equipped with solar heating, radon concentrations appear to arise primarily from soil underlying the buildings. Measures to control higher levels (e.g., by mechanical ventilation with heat recuperation) appear to be economical. However, to evaluate energy-saving programs adequately requires a much more comprehensive characterization of radon sources (for example, by geographical area) and a much fuller understanding of the dynamics of radon and its daughters indoors.

0421
Nero, A.V., Schwehr, M.B., Nazaroff, W.W., and Revzan, K.L. (June 1986) "Distribution of airborne radon 222 concentrations in U.S. homes", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (32 pages). NTIS LBL 18274.

KEYWORD: dose, literature, monitoring, distribution, statistical, radon, home, seasonal, QA, risk, health, lung

A systematic appraisal of radon-222 monitoring data from U.S. single-family homes was developed, using several aggregation approaches, and explicitly considered the differences in sample selection and season of measurements. The resulting distribution of annual-average radon-222 concentrations can be characterized by an arithmetic mean of 1.5 picoCuries/liter (pCi/L), or 55 Becquerels/m3 and a long tail with 1 to 3% of homes exceeding 8 pCi/L, or by a geometric mean of 0.9 pCi/L and a geometric standard deviation of about 2.8. The standard deviation in the means is 15%, estimated from the number and variability of the available data sets, but the total uncertainty is larger because these data may not be representative. Available dose-response data suggest that a 1.5 pCi/L average contributes about 0.3% lifetime risk of lung cancer and that, in the million homes with highest radon levels -- where annual exposures approximate or exceed those received by underground uranium miners -- long-term occupants suffer an added lifetime risk greater than or equal to 2%.

0304
Nero, A.V., et al. (1985) "Characterizing the sources, range, and environmental influences of radon 222 and its decay products", Sci. Total Environ., 45:233-244.

KEYWORD: radon, literature, source, weather, control, home, distribution, exposure

This article discusses (1) efforts to identify and control excessive concentrations of radon-222 and its decay products in residential environments, (2) the importance of pressure-induced flow of soil gas for transport of radon from the ground into houses, (3) available quantitative distribution of U.S. residential levels, and (4) the degree of dependence on geographic location. Experiments on the effectiveness of air-cleaning devices for removing particles and radon decay products indicate the potential and limitations of this approach to controlling radon concentrations.

0763
Nero, Anthony V. (Aug. 1983) "Indoor radiation exposures from Rn and its daughters: a view of the issue", Health Phys. 45(2):277-288.

KEYWORD: radon, health, control, regulation, ventilation, energy, exposure, source, home, risk

Exposure to radon daughters indoors can result in significant risk to the general public, particular people living in homes with much higher than average concentrations. Using U.S. housing as an example, this paper reviews what is known about indoor concentrations, associated risks, and the effect of measures to save energy by reducing ventilation rates. It concludes that, by employing appropriate control measures in homes having unacceptabily high concentrations, the average exposure (and therefore risk) of the general public can remain at its present level, or even decrease, despite programs to save energy by tightening homes.

0634
Nero, Anthony V., Jr. (in press) "Estimated risk from exposure to radon decay products in U.S. homes", Atmos. Environ.

KEYWORD: radon, home, health, risk, exposure, distribution, lung, epidemiology

Recent analyses now permit direct estimation of the risks of lung cancer from radon decay products in U.S. homes. Analysis of data from indoor monitoring in single-family homes yields a tentative frequency distribution of annual average radon concentrations averaging 55 Becquerel (Bq)/m3, with 2% of homes exceeding 300 Bq/m3. Applying occupational epidemiological studies, either directly or using recent advances in lung dosimetry, suggests that the average indoor concentration entails a lifetime risk of lung cancer of about 0.3% or about 10% of the total risk of lung cancer. The risk to individuals occupying the homes with 300 Bq/m3 or more for their lifetimes is estimated to exceed 2%. Risks from the homes with thousands of Bq/m3 are correspondingly higher, even exceeding the total risk of premature death due to cigarette smoking.

0581
Nero, Anthony, V., Jr. (1985) "Indoor concentrations of radon-222 and its daughters: sources, range, and environmental influences", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds.,"Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 43-67.

KEYWORD: radon, health, exposure, distribution, home, source, ventilation, research, literature, statistical, dose, lung

The radiation dose from inhaled daughters of radon-222 constitutes about half of the total effective dose equivalent to the general population from natural radiation. Moreover, it is clear that indoor levels are sometimes 10 or more times higher than outdoor levels, with the actual concentration dependent on a variety of factors. The apparent level of exposures and the associated risk of lung cancer have given rise to research characterizing indoor radon concentrations and the factors affecting them. In the United States, in-home monitoring, where the greatest part of the population dose occurs, has been piecemeal. Nonetheless, data from dozens of areas are available, and a systematic appraisal of these data strongly suggests that annual-average concentrations in single-family houses are approximately lognormally distributed, with a geometric mean in the vicinity of 0.9 picoCuries per liter (pCi/L) radon-222 and a geometric standard deviation of approximately 3. This implies an average residential indoor concentration exceeding 1 pCi/L and perhaps 1 million homes exceeding 8 pCi/L, the approximate equivalent of a recently recommended remedial action standard. The main contributors to the wide range observed are variability in source strengths and ventilation rates, with the former being more important. Variability in the equilibrium between radon-222 and its daughters may be of secondary importance. More complete source characterization lies at the heart of efforts to identify efficiently geographic areas and homes with high concentrations.

0374
Niemela, R., and Toppila, E. (1984) "Concentrations of airborne formaldehyde in modern dwellings with low rates of ventilation", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 105-108. NTIS PB85-104206.

KEYWORD: CH_2O, ventilation, home, exposure, regulation, foreign, Finland, field, architecture

The standard in Finland for maximum formaldehyde levels in non-occupational indoor air is 0.15 mg/m3 in new buildings (built or renovated after Jan. 1, 1983) and 0.30 mg/m3 for older buildings.

Formaldehyde levels have been measured in more than 100 dwellings, mostly detached houses and town houses. Air samples were collected with midget impingers and analyzed by the chromotropic acid method and ventilation rates were measured in 35 rooms in 20 homes. Relationships between formaldehyde concentrations, ventilation rates, and Finnish air quality regulations are discussed.

0029
Nitta, H., and Maeda, K. (1982) "Personal exposure monitoring to nitrogen dioxide", Environ. Int., 8:243-248.

KEYWORD: NO2, field, sampling, personal, exposure, source, model, activity, home, office, appliance

Using a sensitive passive sampler, volunteer housewives and office workers measured short- and long-term personal exposure to NO2 in different seasons. These measurements were compared with the simultaneous measurement of outdoor and indoor concentrations. All measurements indicated the potential of an unvented space heater to increase personal exposure. Without an NO2 source indoors, the mean outdoor concentrations are always highest. A time-weighted indoor/outdoor activity model gives modestly improved estimates of personal exposure over those predicted from measured indoor concentrations alone.

0436
Norsted, S.W., Kozinetz, C.A., and Annegers, J.F. (1985) "Formaldehyde complaint investigations in mobile homes by the Texas Department of Health", Environ. Res., 37:93-100.

KEYWORD: CH2O, home, health, exposure, field, architecture, methodology, dose

The Texas Department of Health sampled for formaldehyde (CH2O) in 443 mobile homes between April 1979 and May 1982 at the request of the occupants. Colorimetric detector tubes were used most frequently to collect samples. CH2O concentrations ranged from below detectable limits (less than 0.5 ppm) to 8.0 ppm. Of homes 1 year of age or less, 27% had mean concentrations equal to or greater than 2.0 ppm versus 11.5% of older homes. The primary health complaints reported were headaches, respiratory discomfort, and eye irritation. No evidence of a dose-response relationship was found.

0530
Nyberg, Philip C., and Bernhardt, David E. (1983) "Measurements of time-integrated radon concentrations in residences", Health

Phys., 45:539-543.

KEYWORD: radon, monitoring, sampling,outdoor, home, QA, exposure, methodology, radiation, dose, health, laboratory, track-etch

Certain areas of the United States exhibit high atmospheric concentrations of radon. The necessary and desirable characteristics of systems to measure concentrations of radon and its progeny on a medium- to long-term basis have been the subject of much study. Generally it is agreed that, for the assessment of chronic health hazards, time-integrated measurements are preferred over instantaneous measurements. This is especially true for radon and its progeny, because their concentrations in air can be affected in many ways and may easily change by a factor of 10 in a matter of hours. Furthermore, because the greatest radiation dose is delivered by the radon progeny, that average concentration is of the greatest concern. Several integrating monitoring techniques have been investigated both in the laboratory and in the homes of several volunteers. Of particular interest are the radon progeny integrating sampling units, the passive environmental radon monitors, and track-etch detectors. All were evaluated in a variety of controlled or semicontrolled environments and were also deployed in several residences.

0378
Nylen, P., Bergqvist, U., Wibom, R., and Knave, B. (1984) "Physical and chemical environment at VDT work stations: air ions, electrostatic fields and PCBs", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 163-167. NTIS PB85-104206.

KEYWORD: ion, video, exposure, office, outdoor, particulate, PCB, source

Video display terminals (VDTs) have been implicated as sources of electrostatic fields, ionic particulates, and polychlorinated biphenyls (PCBs). For male, female, and control group VDT operators, electrical resistance in floors, operators' and VDTs' electrostatic fields, suspended ion concentrations, and PCB concentrations were measured. Significant electrostatic differences were found among the three groups, and the electrostatic fields attracted ionized particles. VDTs in this study did not contribute to indoor PCB levels, but indoor levels were higher than outdoor levels.

0340
Offerman, F.J., Girman, J.R., and Sextro, R.G. (1984) "Controlling indoor air pollution from tobacco smoke: models and measurements", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 1, recent advances in the health sciences and technology", Swedish Council for Building Research, Stockholm, pp. 257-264. NTIS PB85-104180.

KEYWORD: CO, smoking, particulate, model, exposure, control, ventilation, health, regulation

The researchers examined the effects of smoking rate, ventilation, surface deposition, and air cleaning on indoor concentrations of respirable particulate matter and CO generated by cigarette smoke. A general mass balance model is presented that has been extended to include the concept of ventilation efficiency. Following a review of the source and removal terms associated with respirable particles and CO, model predictions are compared to various health guidelines.

0221
Offerman, F.J., et al. (July 1984) "Controlling indoor air pollution from tobacco smoke: models and measurements", Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720 (7 pages). NTIS DE84- 016888/XAB.

KEYWORD: CO, exposure, control, health, regulation, smoking, particulate, model, ventilation

The effects of smoking rate, ventilation, surface deposition, and air cleaning on the indoor concentrations of respirable particulate matter and CO generated by cigarette smoke are examined. A general mass balance model is presented, which has been extended to include the concept of ventilation efficiency. Following a review of the source and removal terms associated with respirable particles and CO, the model's predictions are compared to various health guidelines.

0433
Offerman, F., Hollowell, C., Nazaroff, W., and Roseme, G. (1982) "Low-infiltration housing in Rochester, New York: a study of air-exchange rates and indoor air quality", Environ. Int., 8:435-445.

KEYWORD: NO2, CH2O, field, home, ventilation,energy,CO, exposure, radon, humidity, particulate, architecture, smoking, appliance

A sample of 58 occupied homes in Rochester, NY, most of which incorporated special builder-designed weatherization components, were studied to assess (1) the effectiveness of construction techniques designed to reduce air leakage, (2) the indoor air quality and air-exchange rates in selected airtight houses, and (3) the impact on indoor air quality of mechanical ventilation systems using air-to-air heat exchangers. The "specific leakage area" was measured in each house using the fan pressurization technique. Houses with polyethylene vapor barriers and joint seals were, as a group, 50% tighter than a similar group of houses without such components. Mechanical ventilation systems with air-to-air heat exchangers were installed in nine relatively airtight houses, some of which had gas stoves and/or tobacco smokers. Air-exchange rates, indoor concentrations of radon, formaldehyde, NO2, and humidity were measured in each house for 1-week periods with and without mechanical ventilation. More detailed measurements, including CO and inhalable particulates, were made in two of these houses by a mobile laboratory. In all nine houses, air-exchange rates were relatively low (0.2 to 0.5 air changes/hour) without mechanical ventilation, yet indoor concentrations of radon, formaldehyde, and NO2 were below existing guidelines. Mechanical ventilation systems were effective in further reducing indoor contaminant concentrations. The researchers concluded that, when contaminant source strengths are low, acceptable indoor air quality can be achieved with low air-exchange rates.

0514
Offerman, F.J., Girman, J.R., and Hollowell, C.D. (1981) "Midway house-tightening project: a study of indoor air quality", U.S. Department of Energy, Office of Buildings and Community Systems, Washington, DC 20585 (28 pages). NTIS DE81-030886.

KEYWORD: CH2O, radon, NO2, ventilation, home, field, energy, ventilation, sampling, exposure, methodology, architecture

Indoor air quality was studied in 12 retrofitted houses of the Bonneville Power Administration, Midway Substation Residential Community near Richland, WA. Researchers measured effective leakage areas and average concentrations of NO2, formaldehyde, and radon before and after special house-tightening retrofits. The leakage area was reduced by an average of 32%. Radon and formaldehyde concentrations increased moderately, which would be expected from the estimated average decrease in air-exchange rates. None of the pollutant concentrations measured before or after the retrofits exceeded existing guidelines. Because the pre- and post-retrofit measurements involved only single, relatively short-term samples taken two months apart, uncertainties remain regarding the variability of source strength and occupant activities that affect ventilation. These uncertainties preclude any definitive conclusions that the increases observed are purely the result of the retrofits. A more conclusive study would require measurements of a larger sample of homes for a longer period of time, including simultaneous monitoring of control (unretrofitted) houses.

0415
Offerman, F.J., et al. (1985) "Control of respirable particles in indoor air with portable air cleaners", Atmos. Environ., 19(11):1761-1771.

KEYWORD: particulate, home, ventilation, methodology, control, smoking, EPA$, laboratory

Eleven portable air cleaning devices have been evaluated for control of indoor respirable particles using in situ chamber decay tests. Following injection of cigarette smoke in a room-sized chamber, decay rates for particle concentrations were obtained with and without air cleaner operation for total number concentration and for number concentration by particle size. The size distribution was log normal with a count median diameter of 0.15 um and a geometric standard deviation of 2.0. Without air cleaner operation, the natural mass-averaged surface deposition rate of particles was 0.1 h-1. Air cleaning rates for particles were negligible for several small panel-filter devices, a residential-sized ion-generator, and a pair of mixing fans. Electrostatic precipitators and extended surface filters removed particles at substantial rates; a HEPA-type filter was the most efficient air cleaner studied.

0551
Office of Air Quality Planning & Standards, U.S. EPA (1984) "Estimation of short-term SO2 population exposures", draft report, Research Triangle Park, NC 27711 (49 pages). Not available from NTIS.

KEYWORD: SO2, exposure, model, methodology, health, outdoor, source, NEM, EPA$, NAAQS

Other EPA SO2 studies have raised the question as to how often asthmatics living in the vicinity of power plants are actually exposed to SO2 concentrations 0.5 ppm or greater while exercising. Of particular interest was the degree of protection against such exposures provided by the current National Ambient Air Quality Standards (NAAQS). To answer this question, EPA undertook a population exposure analysis, which combined point source emission modeling, the Expected Exposure (ExEx) Model, and EPA's NAAQS Exposure Model (NEM). An overall SO2 model was developed having two major components: (1) a standard EPA dispersion model and ExEx model and (2) a modification of NEM that takes input from the first component and determines the exposure estimates. The methodology of the study is outlined and discussed. An application of the methodology to five actual utility power plants is presented, and the results are discussed.

0259
Oswald, R.A., et al. (Aug. 1982) "Indoor air pollution: the experience with radon", vol. 1, ISES/Solar Energy Society of Canada Energex 8th Conference, Regina, Sask. p. 46.

KEYWORD: radon,lung,source,energy exposure, architecture, Sweden, ventilation, literature, health, foreign, Canada, track-etch

Increased risk of lung cancer is associated with elevated indoor levels of radon. The principal source of indoor radon is radium in underlying soils and rocks and in building materials. Indoor concentrations of radon can increase as a result of energy-conservation measures that reduce air infiltration and ventilation. Track-etch detectors have been used to measure radon levels in homes in Canada, the U.S., and Sweden. Indoor exposure rates in some areas exceed 20 picocuries/liter.

0020
Ott, Wayne R. (1982) "Concepts of human exposure to air pollution", Environ. Int., 7:179-196.

KEYWORD: multipollutant, literature, exposure, dose, terminology, microenvironment, EPA$, model

A number of exposure studies in a single environmental medium, air, are reviewed to see how various authors have defined the concept of exposure assessment. Unfortunately, many investigators estimated exposures either by relying on data from fixed air-monitoring stations or diffusion models, implicitly assuming that people are in one place, usually their homes, throughout a 24-hour period. However, a second body of literature shows that fixed air-monitoring stations or models do not necessarily reflect actual human exposures, because concentrations observed indoors -- in homes, offices, factories, and motor vehicles -- differ from those found outdoors. To standardize the nomenclature dealing with exposures, detailed definitions are given of such terms as "exposure" and "dose", and of their relationships to time and space.

0001
Ott, Wayne R. (1983-84) "Exposure estimates based on computer generated activity patterns", J. Toxicol. Clin. Toxicol., special symposium issue on exposure assessment, 21 (1&2) 1 pp. 97-128.

KEYWORD: CO, model,SHAPE, exposure, activity, biomonitoring, EPA$

Simulating the movement of people through 14 urban microenvironments, the Simulation of Human Air Pollution Exposure (SHAPE) computer model exposes them stochastically to CO concentrations as they go about their daily activities, thereby generating a 24-hour CO exposure profile of each person. SHAPE combines data from past activity pattern studies and CO microenvironmental field studies to generate a frequency distribution of the maximum daily exposures and blood carboxyhemoglobin (COHb) levels of a representative sample of the population. CO exposures and blood COHb levels of 400 employed persons are computed as an example.

0045
Ott, Wayne R. (Oct. 1971) "An urban survey technique for measuring the spatial variation of carbon monoxide concentrations in cities", Stanford University, Dept. of Civil Engineering, Stanford, CA 94305 (153 pages).

KEYWORD: CO, field, vehicle, personal, exposure, outdoor,sampling

An urban survey technique was developed to determine how representative an urban air-monitoring station is of CO concentrations throughout a city. The survey technique was applied in San Jose, CA, where 1128 samples were collected for 6 months and compared with values recorded simultaneously at San Jose's official air monitoring station. Using a bag sampling approach, all samples were collected at "nose height" within a 13-square-mile grid over the metropolitan area. Three basic strategies were employed to answer specific questions about CO distribution: (1) sampling while walking along downtown streets, (2) random grid sampling, and (3) specialized sampling near the air-monitoring station. Exposures on downtown streets were considerably higher than those at the air-monitoring station and showed poor correlations with those values. Samples from the random locations tended to be lower than values observed at the monitoring station. Measurements made more than 60 meters from a major street were correlated with each other in time, suggesting that urban background levels are spatially uniform but vary with time.

0314
Ott, Wayne R., et al. (1986) "The Environmental Protection Agency's research program on total human exposure", Environ. Int., 12(1-4):475-494.

KEYWORD: exposure, model, methodology, personal, monitor, EPA$, sampling, TEAM, design, statistical, risk, dose

The EPA research program on total exposure to environmental pollution (TEAM) seeks to develop a newly emerging concept in the environmental sciences. Instead of focusing purely on the sources of pollution or their transport and movement through the environment, this research focuses on people and their daily activities. The methodology measures and models the pollutant concentrations found at the physical boundaries of people, regardless of whether the pollutants arrive through the air, water, food, or skin. An emerging new arsenal of miniaturized instruments and statistically representative survey designs for sampling the population of cities have generated significant progress recently in providing the new field data needed for making valid risk assessments. The TEAM study includes: developing measurement methods and instruments, developing exposure models and statistical protocols, conducting microenvironmental field studies, conducting total human exposure studies, validating human exposure models with empirical data, and conducting dosage research investigations.

0201
Ott, Wayne R. (1985) "Total human exposure", Environ. Sci. Technol., 19(10):880-886.

KEYWORD: TEAM, methodology, monitor, personal, exposure, model, risk, dose, EPA$, sampling, design, statistical

Research on total human exposure to environmental pollution focuses on humans as pollutant receptors. This new methodology directly measures and models the pollutant concentrations found at the physical boundaries of people, regardless of whether the pollutants arrive through the air, water, food, or skin. It quantitatively determines whether an environmental problem exists at the human interface and, if so, determines the sources, nature, extent, and severity of this problem. By exploiting an emerging new arsenal of miniaturized instruments and by developing statistically representative survey designs for sampling urban populations, significant progress has been made in recent years in providing previously unavailable human exposure field data needed for making valid risk assessments. This research program includes developing measurement methods and instruments, developing exposure models and statistical protocols, conducting microenvironmental field studies, conducting total exposure studies, validating exposure models with empirical data, and conducting dosage research investigations.

0002
Ott, Wayne R. (June 1981) "Exposure estimates based on computer generated activity patterns", Paper no. 81-57.6, presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: CO, EPA$, model,exposure, SHAPE, distribution, activity, microenvironment, biomonitoring

The Simulation of Human Air Pollution Exposure (SHAPE) model was presented for the first time in this annual meeting paper. This computer model simulates the movement of people through 14 microenvironments in the urban area. It exposes them stochastically to CO concentrations as they go about their daily activities, thereby generating a 24-hour CO exposure profile of each person. SHAPE combines data from past activity pattern studies and CO microenvironmental field studies to generate frequency distribution of the maximum daily exposures and blood carboxyhemoglobin (COHb) levels of a representative sample of the population of a city. In this paper, CO exposures and blood COHb levels are computed to illustrate how the SHAPE model works.

0037
Ott, Wayne R., Willits, Neil, and Switzer, Paul (in press) "Carbon monoxide exposures inside an automobile traveling on an urban arterial highway", SIMS technical report in preparation, Stanford University, Dept. of Statistics, Stanford, CA 94305 (85 pages).

KEYWORD: CO, field, vehicle, interior, statistical, EPA$, model, exposure

A motor vehicle made standardized drives on an urban arterial highway -- El Camino Real -- in California over the 13.5-month period from January 5, 1980, to February 27, 1981. This 11.8-mile segment of roadway (5.9 miles in each direction) includes 20 major intersections. CO concentrations inside the test vehicle were measured using electrochemical monitors, and statistical models were tested relating CO exposures to length of time spent waiting at lights, accelerating, and driving at constant speed. The best model of CO exposures over the year was a seasonal model that predicted the average route exposure as a cosine function with a period of 1 year. Individual 1-minute exposures could be treated as lognormally distributed, and their arithmetic standard deviation was found to be linearly related to the arithmetic mean.

0014
Ott, Wayne R., and Willits, Neil H. (1981) "CO exposures of occupants of motor vehicles: modeling the dynamic response of the vehicle", SIMS technical report no. 48, Stanford University, Dept. of Statistics, Stanford, CA 94305 (52 pages).

KEYWORD: CO, field, vehicle, interior, model, EPA$, exposure

A dynamic model was developed and tested relating CO concentration outside the passenger compartment of a moving vehicle to the exposures of vehicle occupants. An experiment conducted on a test vehicle obtained the parameters required for the model. The model successfully predicted interior CO concentrations as a function of time when external concentrations were known. Test results and applications are discussed.

0669
Ott, Wayne, and Eliassen, Rolf (1973) "A survey technique for determining the representativeness of urban air monitoring stations with respect to carbon monoxide", J. Air Pollut. Control Assoc., 23(8):685-690.

KEYWORD: sampling, design, regulation, EPA$, methodology, QA, CO, model,outdoor,microenvironment,field,exposure,home,monitoring

An air quality survey technique for measuring the horizontal spatial variation of CO concentrations was used to determine how representative an urban air monitoring station is of concentrations throughout the 13-square-mile-area of San Jose, CA. Over a 6-month period, 1,128 samples were collected and compared with the values recorded simultaneously at the station. In downtown, residential, and industrial areas, samples were collected at human head height (1) while walking along congested streets, (2) at random grid points, and (3) in the vicinity of the monitoring station. Pedestrians on downtown streets can be exposed to concentrations above the Federal air quality standards without these values being observed at the air monitoring stations. Away from streets, simultaneous CO concentrations are relatively similar throughout the city. CO concentrations decline rapidly as distance from streets increases. Data from present urban air monitoring stations may not support determinations of compliance with air quality standards as currently defined.

0041
Ott, Wayne, and Funkhauser, Robert (June 1967) "Models for calculating carbon monoxide concentrations on streets", U.S. Public Health Service, Division of Air Pollution, Cincinnati, OH 45268 (74 pages).

KEYWORD: source, vehicle, exposure, model, dispersion, outdoor, CO, microenvironment, interior

One of the first research attempts is described to develop deterministic microscale dispersion models for calculating air pollutant concentrations both near traffic and inside motor vehicles. A plume model is first applied to a single vehicle moving in traffic at a constant speed (single-vehicle case); then multiple-plume models are applied to a number of vehicles traveling along a roadway with several lanes and spacing configurations. Next an emissions submodel is developed to compute emissions for different traffic variables and situations (average speeds, minimum spacing, and traffic volume). Curves and tables are provided allowing the user to estimate emissions for a variety of highway situations, using contemporary emission factors. Finally, simplified line source models are developed to compute concentrations contributed by roadways at various stationary points located very close to the roadways.

0416
Ott, W.R., Rodes, C.E., Drago, R.J., Williams, C., and Burman, F.J. (1986) "Automated data-logging personal exposure monitors for carbon monoxide", J. Air Pollut. Control Assoc., 36(8):883-887.

KEYWORD: CO,personal,exposure,monitor,outdoor,field, methodology, QA, EPA$

In the early 1980s, new miniaturized instruments became available for continuously measuring human exposures to CO. Early tests revealed that people had difficulty writing down the large quantity of data generated by these instruments as they walked on sidewalks, drove, or engaged in other normal activities. Several solutions were considered using microprocessors to sample, manipulate, and store the readings generated by the personal exposure monitors (PEM). Two candidate hardware systems were developed, one that computed and stored the times and average CO concentrations at the command of the user, and another that logged the event codes as well. These efforts led to development of the CO exposure dosimeter (COED) PEMs that were used in the Denver, CO, and Washington, DC, human exposure studies in 1982-83. The COED-I was used successfully to obtain more than 1,600 24-hour human CO exposure profiles in these two cities, and the COED-II was evaluated briefly in test settings. This paper describes the measurement system and microprocessor data logger used in these new monitors.

0003
Ott, Wayne R. (Sept. 1982) "Human activity patterns: a review of the literature for estimation of exposures to air pollution", draft report, U.S. EPA, Office of Research and Development, Washington, DC 20460 (16 pages). Not available from NTIS.

KEYWORD: activity, literature, model,outdoor, exposure, research, EPA$

This paper is one of the few documents available that summarizes, specifically for application to air pollution exposure research and models, the number of studies of human activity patterns and time budgets. More than 30 studies are reviewed, and their possible use in air pollution research is critically evaluated.

0203
Ott, Wayne R. (Feb. 1985) "The Environmental Protection Agency's research program on total human exposure", U.S. EPA, Office of Research and Development, Washington, DC 24060 (50 pages). Not available from NTIS.

KEYWORD: TEAM, methodology, personal, exposure, model, risk,dose, EPA$, monitor, sampling, design, statistical

EPA's research program on total human exposure to environmental pollution focuses on humans as pollutant receptors. The methodology measures and models the pollutant concentrations found at the physical boundaries of people, regardless of whether the pollutants arrive through the air, water, food, or skin. By exploiting an emerging new arsenal of miniaturized instruments and by developing statistically representative survey designs for sampling the population of cities, significant progress has been made in recent years in providing previously unavailable exposure field data needed for making valid risk assessments. This research program includes developing measurement methods and instruments, developing exposure models and statistical protocols, conducting microenvironmental field studies, conducting total exposure studies, validating exposure models with empirical data, and conducting dosage research investigations.

0675
Ott, Wayne R., and Mage, David T. (1974) "A method for simulating the true human exposure of critical population groups to air pollutants", in "Proceedings of the international symposium: recent advances in assessing the health effects of environmental pollution", Paris, France, pp. 2097-2107.

KEYWORD: CO, exposure, monitoring, statistical, outdoor, method, regulation, field, personal, monitor, statistical, methodology

There are serious problems in accurately assessing the true population exposure to air pollutants. In the United States, the primary means for monitoring air quality is by measurements at fixed locations in urban areas. It is becoming increasingly apparent that such data provide a relatively poor measure of the true exposure of members of the general public to air pollutants, because these stations are not necessarily located where the public is exposed to the highest concentrations. To demonstrate a method to obtain a more representative measure of the human exposure of a critical population group, pedestrians collected integrated CO samples over the routes that they walk. A total of 425 of these simulated exposures samples (SES) were collected on congested downtown streets in a major urban area. The results were compared statistically with conventional measurements from a nearby fixed monitoring station. Significant differences were observed between these two methodologies. The significance of these findings for setting air quality standards is discussed.

0031
Ott, Wayne, and Flachsbart, Peter (1982) "Measurement of carbon monoxide concentrations in indoor and outdoor locations using personal exposure monitors", Environ. Int., 8:295-304.

KEYWORD: CO, field, personal, exposure, monitor, outdoor, EPA$, microenvironment

On 15 dates, 5,000 measurements of CO were made downtown in four California cities (San Francisco, Palo Alto, Mountain View, and Los Angeles) using personal exposure monitors (PEMs). Altogether, 588 commercial settings were visited, and indoor and outdoor locations were sampled at each setting. On 11 surveys, two PEMs were carried about 0.15 to 6 meters apart, giving 1,706 pairs of observations that showed good agreement. For a given date and commercial setting, CO concentrations were relatively stable over time, permitting levels to be characterized by making only brief visits to each setting. The data indicate that most commercial settings experience CO concentrations above zero indoors because CO tends to seep into buildings from vehicular emissions outside. Levels in these locations usually are not above 5 ppm and seldom are higher than the 9 ppm National Ambient Air Quality Standard. However, indoor garages and buildings with attached indoor parking areas can have relatively high CO concentrations.

0125
Ott, Wayne, et al. (June 1984) "Application of microprocessors to data logging problems in air pollution exposure field studies", Paper No. 121.2 presented at the 77th annual meeting of the

American Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (6 pages).

KEYWORD: CO, field, methodology, personal, exposure, outdoor, QA, monitor, EPA$

In the early 1980s, new, miniaturized instrumentation became available for continuously measuring human exposures to CO. Early tests revealed that people had difficulty writing down the large quantity of data generated by these instruments as they engaged in their normal activities. Several solutions were considered using microprocessors to sample, manipulate, and store the readings generated by the personal exposure monitors (PEMs). Two candidate hardware systems were developed; one computed and stored the times and average CO concentrations at the command of the user, the other logged the event codes as well. These efforts led to development of the CO Exposure Dosimeter (COED) PEMs that were used in the Denver, CO, and Washington, DC, human exposure studies in 1982-83. COED-I was used successfully to obtain more than 1,600 24-hour human CO exposure profiles in these two cities, and COED-II was evaluated briefly in test settings. This paper describes the measurement system and microprocessor data-logger used in these new monitors.

0609
Otten, J.A., Morey, P.R., Burge, H.A., Chatigny, M.A., Feeley, J.C., and Peterson, K. (1986) "Airborne viable microorganisms in office environments: sampling protocol and analytical procedures", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 36-45. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: microorganism, health, methodology, sampling, industrial, control, exposure

The American Conference of Governmental Industrial Hygienists' Committee on Bioaerosols has developed a draft sampling protocol and analytical procedures for airborne viable microorganisms in offices where workplace-related illnesses such as hypersensitivity pneumonitis, humidifier fever, and allergies (due to bioaerosols) are reported. The protocol specifies these items: (1) rationale for initiating airborne monitoring, (2) sampler selection, (3) culture media selection, (4) sampling strategy, (5) handling and processing of collected microorganisms, (6) data interpretation, and (7) remedial actions. This protocol may serve as a model for developing protocols for diverse occupational settings.

0193
Ozkaynak, H., Ryan, P.B., Allen, G.A., and Turner, W.A. (1982) "Indoor air quality modeling: compartmental approach with reactive chemistry", Environ. Int. 8:461-471.

KEYWORD: NOx, field, model, microenvironment, ventilation,source

Data on indoor/outdoor pollutant and tracer concentrations were collected during different periods in 1981 at a residence in Newton, MA. Special studies within the kitchen were conducted to determine the vertical and horizontal variability of pollutant and tracer gas concentrations. A reactive chemistry model incorporating simplified NOx chemistry was developed to simulate pollutant concentrations indoors. Multicompartmental mathematical modeling tools were also developed and tested to estimate efficiently the effective, emission, ventilation, and removal rates, as well as the intercompartmental pollutant exchange coefficients. Model studies using two- and three-compartment systems and tracer measurements proved that the dynamics of pollutant mixing inside a kitchen is not only complex but may be quite important in controlling the spatial and temporal variability of reactive species. Further monitoring and modeling studies are recommended to investigate the critical aspects of the short-term dynamics of the reactive pollutants inside homes with gas cooking stoves.

0574
Ozkaynak, H., Ryan, P.B., Spengler, J.D., and Laird, N.M. (1986) "Bias due to misclassification of personal exposures in epidemiologic studies of indoor and outdoor air pollution", Environ Int., 12(1-4):389-393.

KEYWORD: model, health, risk, indoor, outdoor, smoking, design, particulate,methodology,QA,statistical,demographic

The authors examine the nature and magnitude of bias resulting in the estimation of relative health risks and risk differences due to misclassifications of exposures and disease. Bias correction expressions depending on the misclassification parameters, sensitivity and specificity, as well as the observed risk indicators, are provided. Examples based on predictions of exposures of adults and children to both indoor and outdoor respirable particles suggest the potential for significant bias toward the null hypothesis if exposure or disease misclassifications are not properly accounted for in the epidemiologic studies of air pollution health effects.

0443
Palmes, E.D., Gunnison, A.F., DiMattio, J., and Tomczyk, C. (1976) "Personal sampler for nitrogen dioxide", Amer. Ind. Hyg. Assoc. J.. 37:570-577.

KEYWORD: NO2, personal, exposure, monitor, sampling, methodology, QA

A new type of personal sampler for gases in air, originally reported by the Institute of Environmental Medicine, New York University Medical Center, has been adapted for measuring NO2. The sampler depends on the transfer of NO2 by diffusion to a triethanolamine-coated collector at the sealed end of a tube; the open end is exposed to the test environment. The devices are accurate, light, simple to use, and have very good shelf life before and after sampling.

0708
Palmes, E.D., Tomczyk, C., and DiMattio, J. (1977) "Average NO2 concentrations in dwellings with gas or electric stoves", Atmos. Environ., 11:869-872.

KEYWORD: source, home, monitor, field, NO2, combustion, exposure, methodology,

NO2 concentrations in dwellings were measured using a passive sampler operating by NO2 diffusion to a sensitive reagent. Concentrations were four times higher in dwellings with gas stoves than in those with electric stoves. Also, NO2 concentrations varied with stove type. The results are similar to other studies. This new sampler does not interfere with residents activities and is easy to operate.

0693
Palmes, E.D., and Tomczyk, C. (1979) "Personal sampler for NO2", Am. Ind. Hyg. Assoc. J. 40:588-591.

KEYWORD: personal, exposure, methodology, sampling, laboratory, NO, NOx, NO2, QA

A personal sampler system for NOx (NO + NO2) and NO2 has been developed for monitoring workplace air. The NO2 sampler previously reported from this laboratory uses triethanolamine to trap NO2 which diffuses through a tube of appropriate dimensions. The NOx sampler contains the same elements as the NO2 device, but it is also fitted with a chromic acid impregnated disc; this disc converts NO to NO2 which is then trapped by the triethanolamine along with preformed NO2. The trapped NO2 in all cases is determined as nitrite colorimetrically and NO is measured by difference between the NOx and NO2 values. The NOx sampler gives accurate and reproducible results if the chromic acid dis is in place for 24 hours or less; it is necessary, therefore, to insert and remove the disc within reasonably short times before and after sampling. We believe, however, that this operation will not be a serious problem for the user.

0101
Pannwitz, Karl-Heinz (Aug. 1984) "Indoor air monitoring by sample taking at solid matrices", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 197-201. NTIS PB85-104214

KEYWORD: organic, sampling, methodology, monitoring

Direct analysis of organic contaminants in the air of housing spaces, for example by a gas chromatograph, is in most cases very difficult because the average concentrations of the pollutants often are in the ppb range. Therefore, it is necessary to enrich the contaminants. Many organic vapors can be adsorbed by activated charcoal. After sampling, the enriched substances are desorbed by an organic solvent and analyzed by gas chromatography. Active and passive samplers, among them the passive sampler "ORSA 5", were compared under defined conditions.

0649
Parker, Carl D., and Strong, R.B. (1974) "Evaluation of portable, direct-reading carbon monoxide meters", U.S. Department of Health, Education,, and Welfare, Center for Disease Control, Cincinnati, OH (148 pages).

KEYWORD: CO, monitor, QA, methodology, economic, laboratory

A market survey was conducted to determine the availability of portable, direct-reading CO meters with a range of approximately 10 to 500 ppm. Selected manufacturers were requested to submit a meter for the evaluation. Performance characteristics of the meters were determined. Physical and performance characteristics of these meters are discussed, and construction, performance, and quality control standards for portable CO meters are recommended.

0545
Parker, G.B., Lee, R.N., and Dennis, G.W., (1983), "Monitoring indoor pollutants in two small office buildings to support a modeling study", U.S. Department of Energy, Washington, DC 20585 (12 pages). NTIS DE84-010900.

KEYWORD: CO, NOx, CH2O, radon, particulate, temperature, outdoor, office, humidity, seasonal, ventilation

The Pacific Northwest Laboratory conducted a study to monitor outdoor and indoor pollutants and to determine air-exchange rates in two small office buildings in the Pacific Northwest, both constructed in the mid-1970s. Radon, particulate matter, CO, NOx, and formaldehyde were measured during approximately a 3-day period in each building during the heating season. Air exchange, temperature, relative humidity, and wind speed were also measured. Average workday indoor pollutant levels of formaldehyde, CO, NOx, and radon were near ambient (outdoor) levels. Concentrations of particulate matter indoors were greater than those outdoors in both office buildings and significantly greater in the second office building as compared to the first. The measurement protocol and measurement results are described. The hourly variations in radon and particulate matter concentration measured in the second building are also given.

0219
Parker, G.B., Wilfert, G.L., and Dennis, G.W. (Nov. 1984) "Indoor air quality and infiltration in multifamily naval housing", Proceedings of the annual 1984 PNWIs/APCA meeting (15 pages). NTIS DE85-005295.

KEYWORD: CO, NO2, smoking, radon, CH2O, particulate, outdoor, field, source, ventilation, architecture, weather, appliance

Indoor air quality and air infiltration were measured in three units of a multifamily housing complex at the Naval Submarine Base in Bangor, WA, over 5 consecutive days during the heating season of 1983. Three dwelling units of identical size constructed in 1978 were monitored, each in a separate two-story four-unit complex. One unit was downstairs and the other two were upstairs. Two of the units were occupied by smokers (one downstairs and one upstairs). None of the units had combustion appliances. Pollutants monitored indoors included radon, formaldehyde, CO, particulate matter, and NO2. Indoor and outdoor temperature and wind speed were also recorded. Outdoor formaldehyde and NO2 were also measured.

0277
Paul, Roy A. (Jan. 1986) "Demographic data for lead exposure analysis", EPA contract no. 68-02-4309, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711 (32 pages). Not available from NTIS.

KEYWORD: Pb,children, distribution, exposure, demographic, model, outdoor, EPA$, pregnancy

A computer program (MATCH-AQ) was developed to calculate the number of children and pregnant women who may be exposed to Pb. Lead concentrations in air were estimated for given point sources within four metropolitan areas: Chicago, IL, Dallas, TX, Nashville, TN, and Tampa-St. Petersburg, FL. Projected demographic group populations are based on 1980 census data and 1990/2000 forecasts by the U.S. Bureau of Economic Analysis. The outputs include geographic, air quality, and population exposure data by each census tract for pregnant women and for children in seven age groups.

0274
Paul, Roy A., and McCurdy, Thomas (June 1986) "Estimation of population exposure to ozone",Paper no. 86-66.2, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (15 pages).

KEYWORD: exposure, activity, pattern, outdoor, model, regulation, seasonal, microenvironment, O3, EPA$, distribution, QA

A version of the National Ambient Air Quality Standard (NAAQS) Exposure Model (NEM-O3) appropriate for analyzing ozone exposure is described. NEM simulates the movement of selected segments of the human population through different geographic areas characterized by different ambient air pollutant levels. Application of NEM-O3 in the New York City metropolitan area is summarized, providing estimates of population exposure for various measures of exposure, and different averaging times, time periods (summer months and ozone season), and exercise levels. Ozone exposure estimates change considerably as different ozone NAAQS are applied. NEM-O3 model results are useful in evaluating impacts of alternative standards, as well as providing input to ozone risk assessments.

0106
Paul, Roy A., Johnson, Ted, Pope, Anne, and Ferdo, Alicia (Feb. 1986) "The NAAQS model (NEM) applied to ozone (draft)", EPA contract no. 68-02-4309, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle, Park, NC 27711 (116 pages). Not available from NTIS.

KEYWORD: NEM, exposure, O3,outdoor, EPA$, microenvironment,model, activity, pattern, QA, regulation, seasonal, distribution

The National Ambient Air Quality Standard (NAAQS) Exposure Model (NEM) can simulate exposure in selected urban areas under user-specified regulatory scenarios. The model requires prepared and validated data on air quality and population activity patterns. NEM for O3 is applied to New York City as an example. Source code versions of the program are available.

0446
Paul, Roy A., and Johnson, Ted (April 1985) "The NAAQS exposure model (NEM) applied to carbon monoxide: addendum", U.S. EPA, Office of Air and Radiation, Research Triangle Park, NC 27711 (31 pages). NTIS PB85-235182/REB.

KEYWORD: CO, model, exposure, NEM, distribution, NAAQS, health, regulation, statistical

This report describes the results obtained when the CO version of NAAQS (National Ambient Air Quality Standards) Exposure Model (NEM) is used to estimate national exposures associated with attaining the current CO standard (9 ppm - 8 hour average - one observed exceedance per year). This standard was not analyzed in the basic report of the same title (BLIS #043). NEM is a model that simulates the intersection of a population with pollutant concentrations over space and time to estimate exposures required to meet various alternative NAAQS. Estimates are presented for adults with cardiovascular disease in four urban study areas and for a nationwide extrapolation.

0077
Pellizzari, E.D., Sheldon, L.S., Sparacino, C.M., Bursey, J.T., Wallace, L., and Bromberg, S. (1984) "Volatile organic levels in indoor air", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 303-308.

KEYWORD: VOC, field, office, home, sampling, method, EPA$

Volatile organic compounds (VOCs) in indoor air in a home for the elderly and a new office building were identified and quantified using Tenax GC samplers and capillary gas chromatography/mass spectrometry. More than 300 chemicals were tentatively identified in indoor air of the nursing home. Night-day levels were compared. The new office building was also part of a longitudinal study that revealed a rapid decrease in levels with time for some chemicals, while others increased.

0211
Pellizzari, E.D., Whitmore, R., Sheldon, L.S., Sparacino, C.M., Zelon, H., and Hartwell, T.D. (1983) "Breath monitoring as an

indication of environmental exposure to volatile organics", draft report, U.S. EPA, Office of Research and Development, Washington, DC 20460 (191 pages). Not available from NTIS.

KEYWORD: VOC, personal, exposure, outdoor, design, biomonitoring, statistical, methodology, QA, EPA$

This report thoroughly documents the design and execution of a survey of volatile organic compounds in personal air, water, and exhaled breath samples of people in and around Los Angeles, CA. Major topics are statistical sample design, survey operations, chemical sampling and analysis, quality assurance, and statistical data analysis. More analytical options are recommended. Personal air levels were usually higher than indoor air or breath levels. Data and data analysis are extensive for each chemical and medium.

0107
Pellizzari, E.D., Zelon, H.S., Bursey, J.T., Leininger, C.C., Hartwell, T.D., and Breen, J. (Aug. 1984) "Sampling and analysis design for volatile halocarbons in indoor and outdoor air", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 203-208. NTIS PB85-104214

KEYWORD: VOC, halocarbon, CHC13,CC14, exposure, QA, field, EPA$, outdoor, statistical

Matched pairs of overnight indoor and outdoor ambient air samples were collected at 146 residences in three areas of the United States. Up to 17 volatile halocarbons were measured in each sample collected on Tenax GC using computerized gas chromatography/mass spectrometry. Controls, blanks, and duplicate field samples were used to assess the accuracy and precision of the overall technique. Analyte recoveries ranged from 79% to 125% for spiked sampling devices, with a relative standard deviation (RSD) of 2% to 3%. Overall median RSDs for indoor and outdoor duplicate samples were 27% and 51%, respectively.

0017
Pellizzari, E.D., et al. (1981) "Total exposure assessment methodology (TEAM) study", vol. I: Northern New Jersey (393 pages), vol. II: Research Triangle Park (189 pages), vol. III: quality assurance (237 pages), EPA contract no. 68-01-3849, U.S. EPA, Office of Research and Development, Washington, DC, 20460. Not available from NTIS.

KEYWORD: PAH, PCB, VOC, metal, pesticide, TEAM,field,methodology, personal,exposure,food,QA,biomonitoring,EPA$,water,seasonal

The total exposure assessment methodology (TEAM) study is described. TEAM is a major effort to measure direct human exposure to four groups of chemicals -- volatile organics, pesticides and polychlorinated biphenyls (PCBs), metals, and polyaromatic hydrocarbons. About 30 chemicals were measured in air, food, water, beverages, and house dust of 12 volunteers in New Jersey and North Carolina over three seasons. The same chemicals were measured in exhaled breath, blood, urine, and hair. About 30 sampling and analytical protocols were field tested. Volatile organics could be included in a full-scale study, but analyses for individual foods would have to be improved before metals and pesticides could be studied further.

0075
Pellizzari, E.D., et al. (1986) "Sampling and analysis for volatile organics in indoor and outdoor air in New Jersey", Environ. Int., 12(1-4):369-387.

KEYWORD: VOC, field, outdoor, QA, statistical, TEAM, EPA$

As part of the Total Exposure Assessment Methodology (TEAM) study, matched pairs of overnight indoor and outdoor ambient air samples were collected from 85 residences in Elizabeth and Bayonne, NJ, and analyzed by computerized gas chromatography/mass spectrometry for volatile organic chemicals. Accuracy and precision for the overall method were monitored by control samples and replicate sampling. Analyte recoveries ranged between 85% and 100% from controls. The intra- and interlaboratory relative standard deviations (RSDs) for sample collection and analysis of duplicates were 20% to 30% and 30% to 45%, respectively. The overall median RSDs were: indoor, 30%; outdoor, 37%; intralaboratory sample analysis, 29%; and interlaboratory sample analysis, 26%.

0220
Pellizzari, E.D., et al. (May 1982) "Human exposure to vapor-phase halogenated hydrocarbons: fixed-site vs. personal exposure", in "proceedings: National symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982", pp. 264-288. NTIS PB-84-148345.

KEYWORD: personal, exposure, monitor, sampling, halocarbon, EPA$, outdoor, methodology

The use of personal and fixed-station monitoring for assessing exposure of populations to halocarbons is discussed. Atmospheric exposure to volatile halogenated hydrocarbons was studied in populations in Baton Rouge, LA, and Greensboro, NC. The relative merits and limitations of fixed-station monitoring systems and personal monitors are addressed. Air sampling values are reported for diverse chlorinated hydrocarbons. The levels of halocarbons in personal air samples were higher than fixed-site samples.

0141
Pellizzari, Edo D., et al. (1984) "Total exposure and assessment methodology (TEAM): dry cleaners study", EPA contract no. 68-02-3626, U.S. EPA, Office of Research and Development, Washington, DC 20460 (159 pages). Not available from NTIS.

KEYWORD: VOC, water, PERC,solvent, biomonitoring,field, personal, exposure, EPA$, outdoor, dry-cleaner, statistical

A special study of workers in dry cleaning establishments was conducted in March and April 1982. Personal exposure to more than 20 volatile compounds via drinking water, ambient air, and personal air was assessed using previously developed sampling and analysis methodologies. Body burden for the target chemicals was determined by measuring levels in breath, blood, and urine. Results were subjected to summary statistical analysis. All of these methods are described in detail. Workers in dry cleaning establishments using perchloroethylene (PERC) as cleaning fluid were exposed to higher levels of PERC at work than elsewhere. Levels in breath, blood, and urine also were higher during work times than other times.

0260
Pengelly, L.D., et al. (Nov. 1983) "The Hamilton study: relationship between outdoor and indoor air quality in homes and elementary schools", Canada Ministry of Environment general and air pollution research technology transfer conference, Toronto, Canada Vol. 1, pp. 184.

KEYWORD: outdoor, NO2, SO2, particulate, school, source,foreign, home, seasonal, Canada

Indoor and outdoor levels of NO2, SO2, and particulates were measured in Hamilton, Ontario, residences and schools. Observations were made for two 5-day sessions at each site, one during the heating season and one during non-heating periods. For NO2, the indoor/outdoor ratio was close to 75% in schools and was independent of heating season; indoor levels were strongly correlated with outdoor concentrations. In homes, the ratio strongly depended on the presence of indoor sources such as stoves. In the absence of these, little effect of heating season was documented, and the ratio was about 80%. Indoor levels of SO2 were also correlated with outdoor levels at all sites.

0179
Pepys, J. (1982) "Chemical dusts, vapours, and fumes causing asthma", Environ. Int., 8:321-325.

KEYWORD: multipollutant, literature, health, lung, allergen

Respiratory disease due to common allergens of organic origin is well known. Less familiar, but of increasing importance, are organic and inorganic chemicals being encountered as dusts, vapors, and fumes. Their relevance is shown in occupational respiratory allergic disorders. Controlled exposure with minute amounts of these chemicals for brief periods closely simulates allergic sensitivity and can precisely identify sources in often complex exposures. The capacity of these widely different agents to elicit various patterns of asthmatic reactions points to their potential role, as well as the role of chemical agents in general as allergens. The introduction into indoor environments of such materials demands consideration of their possible allergenic effects and of the need to recognize the various forms of allergic respiratory reaction they may cause.

0666
Pepys, Jack, et al. (1984) "Immunology/sensitization/irritation panel report", Environ. Health Perspect., 58:343-346.

KEYWORD: methodology, QA, health, CH2O, exposure, dose, research, literature, lung, dermal, epidemiology, allergen

This report summarizes the irritating and allergic effects of inhalation, cutaneous, and eye exposures to formaldehyde. Research methodologies used were evaluated, remaining uncertainties were discussed, and future research needs described.

0578
Perhac, Ralph M. (1985) "Indoor air quality--electric utility concerns", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 3-4.

KEYWORD: energy, economic,health, regulation, exposure, activity, research, ventilation, outdoor, TEAM, architecture

The electric utility industry has an interest and a stake in indoor air quality for two principal reasons. The first relates to energy conservation and the second to ambient air quality standards and the protection of human health. Because of its concern for conservation, the electric utility industry in many parts of the nation has been promoting more extensive use of home insulation, solar-heated homes, and construction of homes and other buildings with low air-exchange rates. All these measures lead to lower air-exchange rates--with the attendant potential concern that pollutants might accumulate indoors and thereby pose a health concern. The second reason deals with human health in general terms of overall activities. Most people spend more than 75% of their time indoors, yet ambient air quality standards are based on outdoor measurements. Further, standards are designed to protect the most sensitive segments of the population, that is, those persons who spend perhaps even more than 75% of their time indoors. If we are to evaluate total exposure to atmospheric pollutants, we need to assess the indoor atmosphere accurately as well as the overall mobility pattern of individuals. Whether or not the indoor environment poses a threat to human health, information on the indoor environment is needed before we can assess total exposure.

0059
Peterson, G.A., and Sabersky, R.H. (1975) "Measurements of pollutants inside an automobile", J. Air Pollut. Control Assoc., 25:1028-1032.

KEYWORD: CO, NO, NO2, O3, vehicle, interior, field

A series of experiments was conducted to determine the concentrations of O3, CO, NO, and NOx inside a car under typical driving conditions. During the summer in the Los Angeles, CA, area, O3 in the passenger compartment may be maintained at relatively low values if the influx of outside air is limited. The low levels were explained by the decay of O3 on surfaces within the compartment. The average concentration of the other pollutants inside the car is about equal to that on the outside. In the current tests, however, measured concentrations did not exceed any of the present standards.

0263
Petreas, M., Liu, K. S., Chang, B. H., Hayward, S. B., Sexton, K. (1986) "Nitrogen dioxide concentrations inside mobile homes", Paper 86-6.8, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, (14 pages).

KEYWORD: NO2, home, CH2O, monitoring, sampling, appliance, seasonal, microenvironment

This paper reports the NO2 findings from the 1984-85 study of formaldehyde and NO2 concentrations in California mobile homes. This age-stratified random sample study was conducted by the California Indoor Air Quality Program in two phases: July and August 1984 and February and March 1985. Participants activated monitors for a 1-week period, with sampling occurring in the kitchen and the master bedroom. Week-long average NO2 concentrations fell within the range reported in the literature for similar studies, although 7% of the results for winter kitchen data were above the national average of 50 ppb. Other general conclusions are: electric-heating homes had lower NO2 levels in both kitchen and bedroom than nonelectric homes; for nonelectric homes, kitchen NO2 levels were significantly higher than bedroom levels.

0758
Petreas, M.X., Twiss, S., Pon, D., and Imada, M. (1986) "A laboratory evaluation of two methods for measuring low levels of formaldehyde in indoor air", Am. Ind. Hyg. Assoc. J., 47:(5)276-280.

KEYWORD: methodology, CH2O, laboratory, sampling, QA, statistical

Two methods for measuring formaldehyde at ppb levels -- the modified pararosaniline (PRA) and the modified chromotropic acid (CTA) -- were evaluated in a laboratory study. A dynamic double dilution system was used to generate controlled test atmospheres of formaldehyde by the catalytic depolymerization of trioxane. Impinger samples were collected from the sampling manifold and analyzed. Both methods demonstrated good precision (3.5% for PRA and 3.4% for CTA, respectively) but differed in accuracy (87.7 +1/-7.5% and 92.5 +1/-4.2%) and collection efficiency (91.9 +/1-6.9% and 98.7 +/1- 4.7%). These differences were mainly due to the use of 1% NaHSO3 as the absorbing solution in the CTA method. Additionally, the NaHSO3 solution can preserve the sample longer, making the modified CTA the method of choice for most non-industrial indoor air sampling.

0713
Pickrell, J.A., Mokler, B.V., Griffis, L.C., and Hobbs, C.H. (1983) "Formaldehyde release rate coefficients from selected consumer products", Environ. Sci. Technol., 17(12):753-757.

KEYWORD: CH2O, monitor, method, laboratory, architecture

Many consumer products release varying concentrations of formaldehyde into the atmosphere. A modification of the Japanese Industrial Standard (JIS) desiccator test was used to measure releases, after conditioning, for 46 samples from six types of consumer products (pressed wood products, clothes, fiberglass insulation, paper, fabric, and carpet). Release rate coefficients were calculated as (ug/g day) and (ug/m2/day) for each product. The eight highest formaldehyde release coefficients were from pressed wood products. Of the 46 samples, 24 had coefficients less than or equal to 100 ug/m2/day; five of the six products were represented. The fraction of total extractable formaldehyde released each day under JIS desiccator conditions at a loading of 21 m2/m3 was calculated. Wood products and carpets released 1-4% of total extractable formaldehyde per day, while fiberglass insulation released 10% per day under the conditions of this 2-day test procedure.

0272
Pitts, J.N., Jr., Wallington, T.J., Biermann, H.W., and Winer, A.M. (1985) "Identification and measurement of nitrous acid in an indoor environment", Atmos. Environ., 19(5):763-767.

KEYWORD: NO2, HNO, health

Differential optical absorption spectroscopy (DOAS) provided direct observations of the formation indoors of ppb levels of gaseous nitrous acid (HONO) from the reaction of ppm levels of NO2 with water vapor. HONO is a respirable nitrate known to convert secondary amines in vitro to carcinogenic nitrosamines. The rate of formation of HONO displayed first-order kinetics with respect to NO2, with a rate of 0.25 (+/- 0.04) ppb/minute per ppm NO2 present. An assumed lifetime of 1 hour for both physical and chemical processes for removing HONO leads to an estimated steady-state concentration of approximately 15 ppb HONO per ppm NO2 present. This relatively high level of HONO associated with NO2-air mixtures raises new questions concerning the health implications of elevated NO2 concentrations in indoor environments.

0319
Pleil, J.D., Oliver, K.D., and McClenny, W.A. (1985) "Volatile organic compounds in indoor air: a survey of various structures", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (15 pages). NTIS PB85-198356.

KEYWORD: VOC, home, halocarbon, solvent, laboratory, seasonal, multipollutant, sampling, EPA$, outdoor

Residents collected indoor air samples in their homes in polished stainless steel canisters. The samples were analyzed for volatile organic compounds (VOCs) using cryogenic sample preconcentration and subsequent capillary column chromatography.

Each homeowner was asked to fill out a questionnaire concerning physical, structural, and activity-related characteristics that could affect VOC concentrations. Simultaneous flame-ionization and electron-capture detection yielded concentration data in a range of from 0.1 to 10 ppb for 19 calibration compounds: propane, vinyl chloride, vinylidene chloride, Freon 113, chloroform, 1,2-dichloroethane, methyl chloroform, benzene, carbon tetrachloride, trichloroethylene, cis-1,3-dichloropropene, trans-1,3-dichloropropene, toluene, 1,2-dibromoethane, tetrachloroethylene, chlorobenzene, o-xylene, benzyl chloride, and hexachlorobutadiene. Certain other compounds could also be identified and quantified based on occasional analyses of appropriate standards. These data are presented in three sample groups: summer indoor, winter indoor, and combined summer and winter outdoor. In addition, some probable correlations between residential characteristics and the occurrence of various compounds in indoor air are discussed.

0402
Poffijn, A., Marijns, R., Vanmarke, H., and Uyttenhove, J. (1985) "Results of a preliminary survey of radon in Belgium", Sci. Total Environ., 45:335-342.

KEYWORD: radon, distribution, foreign, home, exposure, sampling, Belgium, statistical

For a preliminary national survey in Belgium in 1983, indoor radon concentration was determined with passive integrating detectors. In 77 of the 79 houses studied, radon concentration was less than 250 Becquerels (Bq)/m3. The highest reported value was 330 Bq/m3. The frequency distribution is log-normal, with a geometric mean of 41 Bq/m3 and a geometric standard deviation of 1.7. The influence of some human and environmental parameters was also studied. Because of the limited scale of the pilot study, only a trend can be derived.

0163
Prichard, H.M., Gesell, T.F., Hess, C.T., Weiffenbach, C.V., and Nyberg, P. (1982) "Associations between grab sample and integrated radon measurements in dwellings in Maine and Texas", Environ. Int., 8:83-87.

KEYWORD: radon, field, sampling, home,track-etching, statistical, water, seasonal

Radon concentrations were measured in several locations in each of approximately 100 dwellings in central Maine and in Houston, TX. Integrated samples were taken during the heating (or cooling) seasons with commercially available passive alpha track devices, while grab samples were taken when integrated samplers were deployed. Both indoor and outdoor measurements in both areas were distributed lognormally, and the geometric mean of indoor measurements in Maine was three times higher than that of corresponding measurements in the Houston area. The mean of the indoor grab sample measurements was not significantly different from the mean of the indoor integrated measurements, and the degree of correlation between the grab samples and a given indoor integrated sample was nearly as good as between integrated samples taken in different rooms.

0701
Prichard, H.M., Gesell, T.F., Hess, C.T., Weiffenbach, C., and Nyberg, P. (1983) "Integrated radon data from dwellings in Maine and Texas", Health Phys., 45:428-432.

KEYWORD: radon, home, field, distribution, source, architecture, track-etching, monitor, statistical, seasonal

This report presents a preliminary analysis of radon-222 surveys made in the summer and fall of 1980 in Houston, TX, and in the late fall and winter of 1980-81 in several communities in central Maine. Approximately 100 dwellings were surveyed in each area during the season when houses are most likely to be closed to control temperature. The primary objectives of the surveys were to develop baseline data on the distribution of indoor radon concentrations in the two areas, determine the extent of spatial variations within dwellings, add to the understanding of source mechanisms, and evaluate the utility and practicality of a number of air sampling strategies. With the exception of four previously sampled structures in Maine, the houses were selected with no direct knowledge of the radon content of the indoor air. The majority of the Maine houses had previously been involved in a survey of radon-222 in drinking water, and an effort was made to span the range of values noted in that project. Questionnaires regarding a number of housing characteristics were administered during instrument deployment, the results of which will be used in subsequent analyses of the primary data presented here.

0714
Purcell, Gary G. and Harper, Jerome P. (1986) "Studies on energy conservation and indoor air quality sponsored by electric utilities", Paper no. 86-5.1, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (9 pages).

KEYWORD: activity, literature, methodology, ventilation, energy, radon, monitor, home, office, research

The Electric Power Research Institute (EPRI) and various electric utilities are investigating indoor air quality impacts of energy conservation practices. The studies generally measure indoor air quality, air infiltration, and, to a limited extent, occupant activities; and involve anywhere from a few to several hundred or more residential or commercial structures. Some utility-sponsored studies have focused on a single pollutant such as radon, whereas others have addressed many pollutants as well as ventilation related parameters. A number of studies have used passive monitors to maximize the spatial representation but have also monitored more intensively in subsets of buildings. Such studies have contributed knowledge that is needed to better understand local and regional variations in indoor radon concentrations. Several ongoing field studies have explicitly incorporated the effects of home weatherization. To help compare results and arrive at more general conclusions, EPRI has actively promoted data base integration through developments such as the concentration-of-indoor pollutants (CIP) data base.

0403
Put, L.W., DeMeijer, R.J., and Hogeweg, B. (1985) "Survey of radon concentrations in Dutch dwellings", Sci. Total Environ., 45:441-448.

KEYWORD: radon, home, exposure, source, architecture, foreign, field, Netherlands

A survey of radon concentrations in dwellings in The Netherlands reveals a median value of 24 Becquerels (Bq)/m3, with no excessively high values. Correlations between radon concentration and combinations of building parameters are discussed in terms of the various sources of indoor radon.

0052
Pyman, Mark (1981) "Levels of carbon monoxide experienced cycling in central London", National Society for Clean Air, Clean Air, 1: 11.

KEYWORD: CO, field, exposure, vehicle, bicycle, foreign, Britain, outdoor, weather, temperature, QA

A continuous CO analyzer (Ecolyzer 2100) was mounted on the rear carrier of a bicycle that traveled the same route in London, England, on a number of commutes from April to June 1980. No correlation was found between CO levels and wind, rain, dust, or temperature levels, but CO was clearly related to traffic volume. In addition, CO levels were generally higher after the evening rush hour than before the morning rush hour. The maximum CO readings occasionally exceeded 100 ppm, the upper limit of the monitor. On four dates, the morning CO inbound trip averages were 21 ppm, 7.5 ppm, 8.5 ppm, and 16 ppm; the corresponding evening outbound trip averages were 15 ppm, 14 ppm, 15 ppm, and 11 ppm. Bicyclists probably are exposed to similar levels of CO as are car occupants.

0717
Quackenboss, J.J., Spengler, J.D., Kanarek, M.S., Letz, R., and Duffy, C.P. (1986) "Personal exposure to nitrogen dioxide: relationship to indoor/outdoor air quality and activity patterns", Environ. Sci. Technol., 20(8):775-783.

KEYWORD: NO2, combustion, source, monitoring,seasonal, outdoor, personal, exposure, appliance

Personal NO2 exposures and indoor and outdoor concentrations were measured for nearly 350 individuals in the Portage, WI area. Concentrations in homes with gas stoves averaged 18 ug/m3 higher in summer (median indoor/outdoor ratio 2.4) and 36 ug/m3 (median indoor/outdoor ratio 3.2) higher in winter than outdoor levels. Personal exposures were closely related to indoor averages for households with gas stoves (r = 0.85 summer, r = 0.87 winter) and with electric stoves (r = 0.68 summer, r = 0.61 winter); more than 65% of the average day was spent at home, while about 15% was spent outdoors in summer and less than 5% in winter. The association between personal exposure and outdoor levels of NO2 was weakest during the winter for both gas (r = 0.20) and electric (r = 0.28) stove groups. Exposures and time allocations indicate that there was a wide range of variability in personal exposure to NO2 that may not be adequately accounted for by simple stratifications based on cooking fuel type.

0344
Quackenboss, J.J., Kanarek, M.S., Kaarakka, P., Duffy, C.P., Flickinger, J., and Turner, W.A. (1984) "Residential indoor air quality, structural leakage and occupant activities for 50 Wisconsin homes", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 411-420. NTIS PB85-104222.

KEYWORD: radon, CH2O, particulate, NO2, home, sampling, energy, CO, ventilation, exposure, source, architecture, activity

As part of an investigation into the influence of a residential weatherization program on indoor air quality and energy efficiency, a multipollutant survey of the air inside 50 Wisconsin homes was conducted three times during the heating season of 1982-83. Air infiltration, structural leakiness, and the presence and use patterns of indoor air pollutant sources during the same period were measured. Measurements included integrated sampling for NO2, respirable-sized particulates, radon, formaldehyde, and CO. Air infiltration rates were measured using a constant-emission sulfur hexafluoride method; structural leakage area was determined using the fan pressurization ("blower door") technique. Residents recorded use of stove and exhaust fan during each sampling period. Resident activities related to other pollutant sources or intentional ventilation were also recorded. Future data analyses will include a mathematical model of the measured parameters.

0034
Quackenboss, J.J., Kanarek, M.S., Spengler, J.D., and Letz, R. (1982) "Personal exposure monitoring for nitrogen dioxide exposure: methodological considerations for a community study", Environ. Int., 8:249-258.

KEYWORD: NO2,field,personal,exposure, monitor,source, combustion, methodology, activity, microenvironment, model, appliance

Personal exposure to NO2 and time spent in various locations were measured for 66 family members from 19 homes in the Portage, WI, area during March 1981. Passive diffusion NO2 monitors were placed outdoors, in the kitchen, and in one bedroom on each floor of the homes, and were worn by family members. Individuals from gas-cooking homes had significantly higher average NO2 exposures than those from homes using electricity for cooking (mean difference 19.37 ug/m3). In both groups, personal exposures were more closely related to bedroom levels than to kitchen, outdoor, and ambient levels, and also to the proportion of time spent in different locations. These models are capable of explaining nearly 90% of the variation about the mean personal exposure.

0196
Quant, F.R., Nelson, P.A., and Sem, G.J. (1982) "Experimental measurements of aerosol concentrations in offices" Environ. Int., 8:223-227.

KEYWORD: particulate,aerosol,monitoring,office, odor, methodology, QA, office

A new automated version of the piezoelectric microbalance measures the mass concentration of airborne particles. It is designed for near-real-time, unattended, round-the-clock measurements. Measurements comparing within +/- 15% with gravimetrically measured filter samples are documented for a wide variety of aerosols in the 50 ug/m3 to 5.5 mg/m3 range. The instrument measures particle diameters from 10 um down to 0.01 um, including submicron combustion smokes and metallic fumes. The piezobalance, with 1 L/min sample flow, is more sensitive than any other mass-sensing instrument, making it especially suited for measuring low indoor concentrations, even below 50 ug/m3.

0542
Que Hee, Shane S., et al. (1985) "Evolution of efficient methods to sample lead sources, such as house dust and hand dust, in the homes of children", Environ. Res. 38:77-95.

KEYWORD: Pb, particulate, dermal, QA, home,methodology, exposure, field, sampling, biomonitoring, children

Efficient sampling methods to recover Pb-containing house dust and hand dust have been evolved so that sufficient Pb is collected for analysis, thus ensuring that correlational analyses linking these two parameters to blood Pb are not dependent on the efficiency of sampling. Precise collection of loose dust from a 1-unit area (484 cm2) with a Tygon or stainless steel sampling tube connected to a portable sampling pump (1.2 to 2.5 liters/minute) required three sampling periods. The Tygon tube sampling technique for loose house dust less than 177 um in diameter was about 72% efficient with respect to dust weight and Pb collection. A representative house dust contained 81% of its total weight in this fraction. A single handwipe for applied loose hand dust was not efficient or precise enough, and at least three wipes were necessary to recover greater than 80% of the Pb applied. House dusts of different particle sizes smaller than 246 um adhered equally well to hands. Analysis of Pb-containing material usually required at least three digestions/decantations using hot plate or microwave techniques to allow recovering at least 90% of the Pb. The authors recommended that other investigators validate their hand-wiping, house-dust-sampling, and digestion techniques to facilitate comparison of results among studies. The final methodology for the Cincinnati, OH, longitudinal study was three sampling passes for surface dust using a stainless steel sampling tube; three microwave digestions/decantations for analysis of dust and paint; and three wipes with hand wipes with one digestion/decantation for the analysis of six handwipes together.

0327
Rabinowitz, M., Leviton, A., Needleman, H., Bellinger, D., and Waternaux, C. (1985) "Environmental correlates of infant blood lead levels in Boston", Environ. Res., 38:96-107.

KEYWORD: Pb, particulate,water,children, seasonal, paint, source, biomonitoring, model

From a blood Pb survey of 11,837 births, 249 newborns were enrolled in a 2-year, longitudinal study. Their blood leads (PbB) were measured semiannually, and their homes were visited for repeated collections of dust, soil, indoor air, tap water, and paint. Recent refinishing activity and the sizes of nearby streets were recorded. Overall mean PbB was 7.2 micrograms/deciliter at birth. PbB did not vary systematically with age. Each subject's average postnatal PbB correlated highly with the amount of Pb in dust and soil, and with Pb in paint. Dust, soil, and air lead levels correlated with one another. Refinishing activity in the presence of lead paint was associated with elevations of PbB. Water Pb, nearby traffic, weight of recovered dust, race, maternal age, education, and sex were not predictive of PbB. Multivariate models of PbB were constructed that become increasingly predictive with age. Indoor dust Pb, soil Pb, refinishing activity, and season were the independent variables.

0657
Rabinowitz, M., Needleman, H., Burley, M., Finch, H., and Rees, J. (1984) "Lead in umbilical blood, indoor air, tap water, and gasoline in Boston", Arch. Environ. Health, 39(4):299-301.

KEYWORD: Pb, biomonitoring, exposure, water, statistical, source, children, control, food, gasoline, outdoor, sampling,seasonal

A strong statistical correlation was found among the monthly averages of Pb concentration in umbilical cord blood (about 500 births/month), indoor air (12 sites/month), and gasoline sales between March 1980 and April 1981 in Boston, MA. Tap water Pb did not correlate with blood Pb. A Dupont Personal Air Sampler and Millipore disc filter was used in the room where the baby spent most of the day. Water was sampled from the kitchen tap after a 4-liter flush. Averaging methods for taking umbilical blood samples and measuring alkyl lead (for gasoline) sold in Massachusetts are described. Control and regulation Pb added to gasoline are discussed.

0111
Raman, V., Rai, J., Singh, M., and Parashar, D.C. (Aug. 1984) "Determination of SO2 by fixation as morpholine adduct", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 233-238. NTIS PB85-104214.

KEYWORD: SO2, laboratory, methodology, QA

SO2/sulfite is trapped in morpholine solution to give a stable adduct that, when treated with pararosaniline hydrochloride and formaldehyde solutions, yields a violet color with an adsorption maximum at 560 mm. The method avoids the use of mercuric salts and is as sensitive as the West-Gaeke method; SO2 levels as low as 25 ppb can be estimated.

0754
Rank, P., Wesolowski, J.J., and Lyman, D.O. (1984) "Indoor air pollution: why a physician should care", CA/DOH/AIHL/R-255, California Department of Health Services, Berkeley, CA 94704 (10 pages).

KEYWORD: control,health, home, combustion, CO, CH2O, NO2, smoke, ventilation

This report is intended to alert physicians to the importance of indoor air as a health problem and to suggest that in some cases a "diagnosis" can be made and corrective measures recommended. The report discusses CO, formaldehyde, NO2, and tobacco smoke to illustrate simple approaches to ascertain that a problem exists and to do something about it.

0404
Rannou, A., Madelmont, C., and Renouard, H. (1985) "Survey of natural radiation in France", Sci. Total Environ., 45:467-474.

KEYWORD: radiation, source, outdoor, foreign, exposure, radon, methodology, field, France

Natural radiation has been surveyed in France since 1981. The components resulting from external sources (ground and building materials) are assessed using thermoluminescent dosimeters. The internal exposure to radon-222 and the potential alpha energy due to radon daughters are estimated, by passive track detectors in the first case and active dosimeters in the second one. This paper presents the French program methods and results with an analysis of the observed levels.

0614
Rao, M.V.R. Koteswara (1986) "Approaches to air pollution monitoring and control in submarines", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 95-103. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: exposure,source,SbH3,CO2,VOC,foreign,SO2,CO,methodology, ventilation,control,mercaptan,India,hydrocarbon,submarine,Cl,NO

While assessing the air quality in submarines, researchers in Bombay, India, prepared and calibrated chemical detector tubes. Samples were taken for chlorine, stibine (SbH3), mercaptans, sulfur acid aerosol, and NO. The usefulness of the adsorbents (e.g., activated carbon and molecular sieves) is also discussed. All these measuring devices and adsorbent columns help to establish maximum allowable concentrations for toxic gases and vapors generated in closed submarine chambers while under water.

0335
Reed, Charles E., and Swanson, Mark C. (1986) "Indoor allergens: identification and quantification", Environ. Int., 12(1-4):115-120.

KEYWORD: particulate, allergen, outdoor, control, exposure, VOC, laboratory, health, methodology

A large number of allergens occur in the air of the home and many work sites. Almost any organic dust or volatile chemical reactive with proteins can cause allergic respiratory diseases: allergic rhinitis, asthma, and hypersensitivity pneumonitis (extrinsic allergic alveolitis). If the exposure continues several years after the disease begins, there may be permanent disability; therefore, recognition and control of exposure are important. Techniques now exist to sample the particulate antigens suspended in the air and assay them by sensitive immunochemical methods.

0405
Reineking, A., Becker, K.H., and Porstendorfer, J. (1985) "Measurements of the unattached fraction of radon daughters in houses", Sci. Total Environ., 45:261-270.

KEYWORD: radon, particulate, foreign,smoking,home,model,exposure, source, Germany, ventilation

The influence of particle concentrations on the activity concentrations of the attached and unattached short-lived radon daughters was determined in rooms of houses in southern Germany. Radon activity concentrations ranged between 150 and 900 Becquerels/m3. Particle concentrations and the unattached fraction were measured in poorly and moderately ventilated rooms. Rooms with higher particle concentrations or with larger particle sizes due to special aerosol sources (cigarette smoke, cooking, stove heating) had the lowest concentrations of unattached radon daughters. In a second part, the attached rate, the plateout rates, and the average attachment diameters of the room aerosols were derived from the measured data by model calculations.

0338
Reinert, Joseph C. (1984) "Pesticides in the indoor environment", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 1, recent advances in the health sciences and technology", Swedish Council for Building Research, Stockholm, pp. 233-238. NTIS PB85-104180.

KEYWORD: pesticide, exposure, literature, health, home, EPA$

The classes of pesticides most commonly used in the indoor domestic environment are characterized, and the annual use of the most frequently used active ingredients is estimated. The information available on observed indoor air levels of pesticides is summarized. Pesticide poisoning incidents in the home are discussed, and current activities in EPA's Office of Pesticide Programs relating to the indoor use of pesticides are described.

0069
Repace, J.L., and Lowrey, A.H. (1982) "Tobacco smoke, ventilation, and indoor air quality", Am. Soc. Heat. Refrig. Air Cond. Eng. Trans. 88 (Part 1):895-914.

KEYWORD: particulate, literature, smoking, combustion, source, ventilation, EPA$, office, aircraft

Factors determining concentrations of tobacco smoke are investigated in a dinner theater, reception hall, and church bingo hall. The predictions of a model using ventilation rates specified by the American Society of Heating, Refrigeration, and Air Conditioning Engineers as surrogates for effective ventilation rates are found to be close to measured values of respirable particulates. The effect of mixing on removal of point-source generated tobacco smoke is examined in a computer office building; circulating fans are found to approximate a volume-diffused source very well. Little difference is found among the decay rates of particulates from cigarettes, cigars, and pipes. Pollutant concentrations from mainstream and sidestream emissions of high- and low-tar cigarettes, cigars, and pipes are contrasted. Emissions of CO from a large cigar are 30 times greater than those of an average cigarette, and, in a large poorly ventilated office, exceed 9 ppm, the 8-hour National Ambient Air Quality Standard for CO within 20 minutes. Smoking on passenger aircraft is discussed.

0086
Repace, J.L., Lowrey, A.H. (1985) "A qualitative estimate of nonsmokers' lung cancer risk from passive smoking", Environ. Int., 11:3-22.

KEYWORD: risk, distribution, exposure, lung, health, smoking, EPA$

Nonsmokers' risks of lung cancer from passive smoking are estimated. According to these preliminary estimates, U.S. nonsmokers are exposed to 0 to 14 mg tobacco tar/day, and the typical nonsmoker is exposed to 1.4 mg/day. An exposure-response relationship is derived, yielding five lung cancer deaths/year/100,000 persons exposed/mg daily tar exposure. This relationship yields lung cancer mortality rates and mortality ratios for a U.S. cohort which are within 5% of the results of the large prospective epidemiological studies of passive smoking and lung cancer in the United States and Japan. Aggregate exposure to ambient tobacco smoke is estimated to produce about 5,000 lung cancer deaths per year in U.S. nonsmokers aged up to 35 years, with an average loss of life expectancy of 17 +/- 9 years/fatality. The estimated risk to the most-exposed passive smokers appears to be comparable to that from pipe and cigar smoking. Mortality from passive smoking is estimated to be about two orders of magnitude higher than that estimated for carcinogens currently regulated as hazardous air pollutants under the Federal Clean Air Act.

0072
Repace, James L. (1983) "The dosimetry of passive smoking", Forbes, William F., Frecker, Richard C., and Nostbak, Ken, Eds. "Proceedings of the 5th world conference on smoking and health, Winnipeg, Canada, 1983", Canadian Council on Smoking and Health, Ottawa, Canada K1Z5G7, pp. 191-198.

KEYWORD: particulate, literature, smoking, health, dose, model, EPA$

The public health community has been slow to recognize the risks to the nonsmoker from breathing indoor air polluted by tobacco smoke (so-called passive or involuntary smoking). Part of the reason may lie in the historical lack of quantification of nonsmokers' exposures and doses. Studies designed to quantify such exposures are reviewed, and a single-compartment model is developed for translating daily exposure for nonsmokers into doses of 5 to 160 mg of tobacco tar. The average U.S. nonsmoker is estimated to have an equilibrium lung dose of 16 mg tobacco tar. The U.S. Surgeon General has asserted that active smoking is a major cause of cancers of many organs of the body, is causally related to coronary heart disease, and is a leading contributory factor in respiratory disease mortality, and also that there is no safe level of consumption. Thus, the modeled doses from passive smoking, being well within the range of exposure to active smoking, suggest that there is a good foundation for the belief that indoor air polluted with tobacco smoke poses a significant threat to the health of nonsmokers.

0071
Repace, James L., and Lowrey, Alfred (June 1983) "Modeling exposure of nonsmokers to ambient tobacco smoke", Paper no. 83-64.2, presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (20 pages).

KEYWORD: particulate, model, smoking, exposure,epidemiology, EPA$

Exposure of the nonsmoking U.S. population to the particulate phase of tobacco smoke in buildings has been modeled. The range of exposure, modeled in earlier work, was estimated to be 0 to 14 mg of tobacco tar/day. This work estimates that the average U.S. nonsmoker of working age receives an exposure of 1.4 mg/day, a weighted average taken over exposures encountered both at home and at work. The ratio of workplace dose to the dose received at home is nearly 4:1, indicating that, on the average, the workplace is a more important source of exposure than the home environment. Such estimates of exposure should prove useful for assessing exposure in epidemiological studies of passive smoking, for assessing carcinogenic risk, and for estimating total population exposed in epidemiological studies of the health effects of particulate air pollution.

0066
Repace, James L. (1981) "The problem of passive smoking", Bull. N.Y. Acad. Med., Ser. 2, 57(10):936-946.

KEYWORD: particulate, health, ventilation, exposure, literature, control, smoking, EPA$

Within the past 2 years, substantial new evidence concerning the adverse health effects of passive smoking has emerged. Well-known health effects of smoking may be suffered by nonsmokers who breathe air contaminated with tobacco smoke. Concentrations of tobacco smoke indoors are directly proportional to smoke density and inversely proportional to the effective ventilation rate. Attempts to control smoking by ventilation are futile, requiring quite uneconomical ventilation rates, and are contrary to the current trend toward energy conservation in buildings. Other ways to reduce the source are more effective.

0152
Repace, James L. (1985) "Passive smoking has no place in the workplace", Can. Med. Assoc. J., 133:737-738.

KEYWORD: health, smoking, risk, ventilation, lung, EPA$, control

Quantitative risk assessment is used to calculate the number of cancer deaths per year attributable to passive smoking in the workplace. The risk to nonsmokers is not reduced by ventilation systems that recirculate the smoke. The only ways to reduce the risk of passive smoking to an acceptable level may be to either separate smokers and nonsmokers into areas with different ventilation systems or ban smoking in the workplace. Examples are given of employers who have banned smoking or limited smoking to a few areas.

0064
Repace, James L., and Lowrey, Alfred H. (1980) "Indoor air pollution, tobacco smoke, and public health", Science, 208:464-472.

KEYWORD: particulate, literature, exposure, model, smoking, EPA$

An experimental and theoretical investigation is made into the range and nature of the exposure of the nonsmoking public to respirable suspended particulates from cigarette smoke. Observed levels of particulates correlated with the predictions of a model incorporating both physical and sociological parameters. Nonsmokers are exposed to significant air pollution burdens from indoor smoking. Public health policy implications are assessed.

0137
Repace, James L., and Lowrey, Alfred H. (1985) "An indoor air quality standard for ambient tobacco smoke based on carcinogenic risk", N.Y. State J. Med., 85:381-383.

KEYWORD: health, lung, control, smoking, ventilation, EPA$, risk, office

An indoor air quality standard for ambient tobacco smoke in U.S. workplaces is derived based on limiting involuntary carcinogenic risk to nonsmokers to the maximum level considered acceptable by Federal regulatory agencies for environmental carcinogens in air, water, or food. This risk level corresponds to a 1-in-100,000 chance of contracting fatal lung cancer in a working lifetime of 40 years. To achieve acceptable risk, the daily average air concentration of tobacco for a typical office must not be more than 0.75 ug/m3. At typical smoking occupancies for an office environment, achieving this standard would require impractical amounts of ventilation or prohibitive costs for air-cleaning equipment. It appears that the only practical control measures are to put smokers and nonsmokers on different ventilation systems, or to ban smoking in the workplace.

0065
Repace, J.L., Ott, W.R., and Wallace, L.A. (June 1980) "Total human exposure to air pollution", Paper no. 80.61.6, presented at the 73rd annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (26 pages).

KEYWORD: particulate, CO, literature, personal, exposure,monitor, microenvironment, activity, vehicle, interior, EPA$

The concept of total human exposure to air pollution is defined theoretically as the time-weighted sum of concentrations of air pollutants encountered in the microenvironments through which people progress in their daily activities. Only by personal monitoring of air pollutants, coupled with time-budget studies, can total air pollution exposures be assessed. Experimental data using personal exposure monitors for respirable particulates and CO are presented to show the efficacy of this technique. The importance of indoor and in-transit exposures relative to outdoor exposures is shown for the first time. Time-resolved personal exposures to CO and respirable particulates indicate that some individuals encounter the greatest contributions from in-transit and indoor microenvironments, and suggest a general population trend that needs further investigation. The relative merits of various types of personal monitors are discussed.

0559
Repace, J.L., and Lowrey, A.H. (1986) "A rebuttal to criticism of a quantitative estimate of nonsmokers' lung cancer risk from passive smoking", Environ. Int., 12(1-4):33-38.

KEYWORD: smoking, methodology, exposure, risk, health, lung, statistical, demographic, literature, EPA$

In letters to and an article in this journal (BLIS #556, #557, and #558), Johnson, Burch, and Kilpatrick have suggested, respectively, that (1) nonsmokers may not be exposed to sufficient smoke to cause disease, (2) tobacco smoke may not cause lung cancer in smokers, (3) the domestic exposure assessment is overestimated, and (4) exposure of a nonsmoker requires the physical presence of an active smoker for the duration of the exposure, each of which, in their view, casts doubt upon the risk assessment. In general, this criticism overlooks the empirical consistency of the methodology that first attempts both to provide a framework for understanding concentrations of tobacco smoke observed under natural conditions, and to elucidate factors affecting nonsmokers' exposures. This work was then used to interpret the growing body of epidemiological and biochemical evidence that exposure to the carcinogenic by-products of tobacco combustion at environmental concentrations creates a significant risk of lung cancer. To assess the level of uncertainty in their calculations, Repace and Lowrey repeatedly show that their estimates of exposure and response are consistent with empirical data.

0070
Repace, James L. (1982) "Indoor air pollution", Environ. Int., 8:21-36.

KEYWORD: particulate, literature, regulation, health, EPA$

As national trends accelerate toward reducing ventilation and infiltration rates in buildings and as use of synthetic chemicals in the indoor environments increases, a new phenomenon has arisen: the "sick building" syndrome. A comprehensive approach to indoor air pollution is necessary to protect public health, because traditional approaches to environmental health developed for outdoor air or industrial settings are inadequate to deal with this problem.

0068
Repace, James L. (1985) "Risks of passive smoking", Gibson, Mary, Ed., "To breathe freely: risk, consent, and air", Rowman and Slanheld, Totowa, NJ 07512, pp. 3-30.

KEYWORD: particulate, regulation, literature, smoking, risk, EPA$

Risks to nonsmokers from breathing indoor air pollution from tobacco smoke are discussed from medical, legal, social, historical, and philosophical points of view. Problems encountered by nonsmokers who are hypersensitive to tobacco smoke are contrasted with chronic risks to normal smokers. Ambient tobacco smoke is compared to hazardous outdoor air pollutants and products of other regulated activities. Failure to regulate indoor smoking will invite increasing confrontation and social dissension among nonsmokers, smokers, and employers, since nonsmokers' right to clean indoor air is morally superior to the smokers' right to pollute.

0317
Ressl, Robert A., and Ponder, Thomas, Jr. (1985) "Field experience with four portable VOC monitors", U.S. EPA,

Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (66 pages). NTIS PB85-165496/AS.

KEYWORD: VOC, personal, exposure, monitor, methodology, QA, EPA$

This report discusses the field operation problems associated with using four portable volatile organic compound (VOC) instruments in conducting Reference Method 21 VOC screenings. Information on operational problems and recommendations is provided. Also included are discussions of the features that would make all portable instruments more reliable, durable, or convenient to use. Three of the instruments report similar leak rates in the facility where they were used.

0594
Riggin, Ralph M., and Petersen, Bruce A. (1985) "Sampling and analysis methodology for semivolatile and nonvolatile organic compounds in air", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 351-359.

KEYWORD: PAH, VOC, PCB, dioxin, methodology,QA,research,sampling, monitoring,exposure,laboratory,pesticide,personal

In the choice of sampling and analysis methods for organic compounds, volatility is a prime consideration. Operationally, compounds can be classified as volatile, semivolatile, and nonvolatile. Chemical reactivity, photochemical reactivity, and data quality requirements must also be considered. Powerful new methods are available for the polynuclear aromatic hydrocarbons, polychlorinated biphenyls, pesticides, and dioxins. Urgent research and development needs include studies of sampling systems for indoor use, pollutant interactions, personal exposure monitors, and quality control for sampling adsorbents.

0146
Riordan, Courtney (1984) "Human exposure to environmental pollutants", J. Toxicol. Clin. Toxicol., 21(1&2):1-8.

KEYWORD: CO, VOC, TEAM, model, personal, exposure, monitor, EPA$

A brief synopsis of the current state of human exposure assessment is presented. EPA research programs on (1) modeling of component exposures and human activities and (2) actual human exposure measurements are highlighted. The EPA-funded field study of CO exposures of people in Washington, DC, and Denver, CO, is an example of studies of this type that allow validation of methods, models, and technologies as well as provide exposure data. The Total Exposure Assessment Methodology (TEAM) program's measurement of volatile organic compounds using personal exposure monitors is discussed.

0440
Ritchie, I.M., and Lehnen, R.G. (1985) "An analysis of formaldehyde concentrations in mobile and conventional homes", J. Environ. Health, 47:300-305.

KEYWORD: CH2O, exposure,home,odor,source, seasonal, architecture, statistical

This paper explores the factors affecting observed formaldehyde (CH2O) concentrations in a retrospective study of 397 mobile and 489 conventional homes. Three classes of variables were analyzed for relationships to observed CH2O levels: structural characteristics of the dwelling, environmental characteristics, and social characteristics. CH2O concentrations in all homes ranged from the limit of detection (0.01 ppm) to 5.52 ppm. Mobile homes on the average had consistently higher CH2O concentrations than conventional homes. About 54% of mobile homes (compared to only 8% of conventional homes) had concentrations greater than 0.03 ppm, which is one-tenth of the current time-weighted, 8-hour concentration allowable in the workplace. Manufacture methods, age of home, month of sampling, and the presence of odor were statistically significant variables associated with higher CH2O concentrations in mobile homes. The statistically significant variables in conventional homes were age of home, month of sampling, and presence of odor. Urea-formaldehyde foam insulation and remodeling were not significantly associated with higher CH2O concentrations in conventional homes.

0096
Ritchie, I.M., and Arnold, F.C. (Aug. 1984) "Characterization of residential air pollution from unvented kerosene heaters", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 253-258. NTIS PB85-104214.

KEYWORD: SO2, NO, NO2, model, kerosene, source, home, appliance, exposure

The study investigated the generation of pollutants from unvented kerosene convective and radiant heaters in a residence. Measured concentrations of CO were low during a 3-month period. However, concentrations of SO2, NO, NO2, and CO2 reached or exceeded levels recommended for indoor air. Further, using a semi-open door to provide ventilation did not reduce concentrations of pollutants to acceptable levels. A comparison based on mass balance modeling is also presented.

0261
Rivers, R.D. (Jan. 1982) "Predicting particulate air quality in recirculatory ventilation systems". In: "Proceedings of the semiannual symposium of the American Society of Heating, Refrigeration and Air Conditioning Engineers", ASHRAE, 1791 Tullie Circle N.E., Atlanta, GA 30329, p. 929.

KEYWORD: particulate, ventilation, outdoor, control, method,model

Systems parameters (such as airflow rates, internal contaminant generation rates, outdoor air quality, and filter efficiency) are given reasonable values and used to predict indoor air quality. A calculation scheme applicable to a wide range of system configurations and operating conditions is also presented. Two general types of systems are considered: one with no parallel flows and those with parallel airflows and multiple zones. Mass balance equations are provided for both. Other factors considered in the calculations of air quality are particle size distributions, outdoor dust concentrations, and vertical distribution of dust concentrations. Penetration vs. particle diameter and dust-loading characteristics of air cleaners are examined briefly.

0469
Roessler, C.E., Roessler, G.S., and Bolch, W.E. (1983) "Indoor radon progeny exposure in the Florida phosphate mining region: a review", Health Phys., 45(2):389-396.

KEYWORD: radon, indoor, distribution, source, risk, literature, control, architecture

This paper reviews the data on land radioactivity and indoor airborne radon progeny associated with mined and reclaimed phosphate lands in Florida. Highest indoor radon progeny levels are associated with the slab-on-grade type of construction. Concentrations exceeding 0.03 working level (WL) are associated with overburden soils, deposits, and fill, while concentrations up to about 0.03 WL are associated with tailings. The lower limit for distinguishing increases above nonenhanced natural concentrations is on the order of 0.01 to 0.02 WL. This study shows that about 25% of the land produced by present methods of mining and reclamation practices would require restrictions on the type of construction or would require special construction methods. The authors suggest that, with modification of mining and tailings disposal practices, virtually all land produced by mining and reclamation would be satisfactory for unrestricted construction use.

0164
Rogozen, Michael B. (1982) "Dynamic simulation of radon daughter concentrations in apartments using solar rockbed heat storage", Environ. Int., 8:89-96.

KEYWORD: radon, model, energy, home, architecture, weather

In solar rockbed storage systems, heat is transferred during the day from the collector to a bed of pebbles and released at night to warm the living area. When the rocks used for storage contain significant concentrations of uranium, radon-222 and its daughters may be released to the living area. A microcomputer model was used to simulate variations in air filtration rate and source strength through several days of operation. Source strengths were estimated from theoretical considerations and literature data. Resulting Rn-222 and daughter concentrations were computed by solving system equations by fourth-order Runge-Kutta integration. During the day, when the living area is isolated from the radon source, interior Rn-222 concentrations approach those of the outdoors. A nighttime steady-state concentration is approached about 6 hours after heat discharge begins. Due to the dynamic nature of the simulation, equilibrium between Rn-222 and its daughters is not reached. Time-weighted average nighttime exposures (6 p.m. to 8 a.m.) for 10 simulation runs varied from 0.001 to 0.018 working level (WL). Comparison with one set of measurements tended to overpredict concentrations but to approximate well the Rn-222 buildup rate.

0694
Rose, Vernon E., and Perkins, Jimmy L. (1982) "Passive dosimetry state-of-the-art review", Am. Ind. Hyg. Assoc. J., 43(8):605-621.

KEYWORD: literature, CO, NO2, SO2, monitor,CH2O, methodology, QA, laboratory, field, sampling

The history of the development and validation testing of passive dosimeters is reviewed. Theoretical considerations, including possible limiting factors or interferences, are presented. Laboratory and field validation tests critically are reviewed and results are presented for comparative purposes. The available data indicate that passive dosimetry, with some exceptions, is an acceptable method for monitoring gases and vapors. Most importantly, passive systems appear to be as reliable as the Accepted active sampling systems.

0626
Ross, Howard, and Berg, David, Eds. (1981) "Workshop on indoor air quality research needs", U.S. EPA and and U.S. Department of Energy, Interagency Research Group on Indoor Air Quality, Washington, DC (199 pages). NTIS DE81-026488.

KEYWORD: multipollutant, EPA$, VOC,exposure methodology,personal, health, control, economic, monitor, model, radon, research

The Workshop on Indoor Air Quality Research Needs, held in December 1980 in Leesburg, VA, was intended to (1) define a research agenda focused on pollutants, sources, measurement methods and instruments, controls, and risks; (2) complete a review of the knowledge base; (3) complete an inventory of recent and ongoing research; and (4) comment on a research strategy. Four technical sessions covered the areas of monitoring, instrumentation, health effects, and controls. Two plenary sessions covered risk assessment and radon. The report includes appendices on selecting a dust monitor, the state of the art in organic vapor monitoring, and research recommendations for monitoring indoor air quality.

0289
Rowe, D.R., Nouh, M.A., Al-Dhowalia, K.H., and Mansour, M.E. (Jan. 1985) "Indoor-outdoor relationship of suspended particulate matter in Riyadh, Saudi Arabia", J. Air Pollut. Control Assoc., 35(1):24-26.

KEYWORD: particulate, outdoor, regulation, foreign, Saudi Arabia, field

Total suspended particulates (TSP) and inhalable particulates (IP) were measured indoors and outdoors in the engineering laboratories in the College of Engineering at King Saud University in Riyadh, Saudi Arabia. The sampling devices and methods are described. Average TSP outdoors was 662 ug/m3, the indoor average was 167 ug/m3, and the average indoor-outdoor ratio was 0.25. The average number of outdoor IP (less than 10 um in diameter) was 137 ug/m3, the indoor average was 78 ug/m2, and the average indoor-outdoor ratio was 0.59. The IP average geometric mean diameter outdoors was 1.54 um, while indoors it was 1.33 um. Both indoor and outdoor exposures should be considered in the establishment of air quality standards.

0291
Ruh, Carmen (Aug. 1984) "The indoor biocide pollution: occurrence of pentachlorophenol and lindane in homes", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for

Building Research, Stockholm, pp. 309-315. NTIS PB85-104214.

KEYWORD: pesticide, lindane, sampling, particulate,biomonitoring, PCP, home

Wood and household dust as well as blood of inhabitants were analyzed for pentachlorophenol (PCP) and lindane to demonstrate the indoor biocide pollution potential of these chemicals. More than 90% of wood samples examined had PCP in the mg/kg range and lindane levels in dust corresponded with the high percentage of positive findings in wood samples. Whole blood values varied from sub-ppb up to 110 mg/kg PCP.

0773
Russel, Michael A.H., and Lebowitz, Michael D. (1984) "Effects on health of environmental tobacco smoke: work group results", Eur. J. Respir. Dis., 65 (Supplement No. 133):140-142.

KEYWORD: source, particulate, risk,health,dose,research, smoking, acrolein

The workgroup on health effects considered both known and potential health effects of exposure to environmental tobacco smoke. Animal research relating to cause and effect mechanisms were discussed. An attempt was made to determine the certainty of the present knowledge and the extent of the health problems associated with tobacco smoke. The group examined acute effects (headaches, annoyance, irritations, difficult breathing) and chronic effects (allergic sensitization, cancer, coronary artery disease). Potential risks--to pregnancy, to migraine sufferers--is discussed. Future recommended recommended included other possible agents and confounding factors (microenvironmental, social).

0093
Ryan, B.P., Spengler, J.D., and Letz, R. (1986) "Estimating personal exposure to NO2", Environ. Int., 12(1-4):395-400.

KEYWORD: NO2, microenvironment, model, exposure, distribution, statistical, methodology

Results of several simulations of NO2 exposure are presented. A Monte Carlo approach is taken in which the parameters of a typical microenvironment model are selected from distributions characterized by the means and variances of the parameters as determined in field studies. Results indicate both the utility of this technique for determining exposure distributions and the potential for misclassification of individuals in categories with overlapping distributions.

0454
Ryan, P.B., Spengler, J.D., and Letz, R. (1983) "The effects of kerosene heaters on indoor pollutant concentrations: a monitoring and modeling study", Atmos. Environ., 17(7):1339-1345.

KEYWORD: NO2, SO2, home, model, combustion, source, field, monitoring, kerosene, appliance

The increased use of kerosene heaters as a supplementary heat source is providing a new source of indoor air pollutants. By-products of kerosene combustion (including NO2 and SO2) are typically found in residences using these appliances. A two-phase study was undertaken, which included both monitoring in the field and modeling. Monitoring for NO2 (using passive diffusion samplers) showed indoor concentrations that ranged from 50 to 300 ug/m3 in buildings using kerosene heaters and no other open combustion sources. Modeling of both NO2 and SO2 concentrations and exposures suggests the possibility of having very high pollutant concentrations in residences that are poorly ventilated or have small-mixing volumes.

0165
Sachs, H.M., Hernandez, T.L., and Ring, J.W. (1982) "Regional geology and radon variability in buildings", Environ. Int., 8:97-103.

KEYWORD: radon, source, literature, ventilation, home

Radon concentrations in dwellings vary by more than two orders of magnitude. Predicting where and when concentrations are likely to be high requires studying the variability of the contributors to radon in buildings. Among common sources, geological factors (water supply and substrate) are the most variable, whereas building materials are much less variable. Ventilation variation among houses is generally responsible for radon variations comparable to those introduced by building materials. However, ventilation variation is more significant at lower ventilation rates. In some regions with relatively high proportions of houses with elevated radon concentrations, mappable geological factors are associated with most cases of high radon concentrations. However, a priori identification of rock types likely to be implicated is unlikely to succeed.

0537
Saffiotti, U., et al. (1965) "Experimental studies of the conditions of exposure to carcinogens for lung cancer induction", J. Air Pollut. Control Assoc., 15(1):23-25.

KEYWORD: health, particulate, benzo-a-pyrene, exposure, dose, lung

An experimental method is described for inducing lung cancer in Syrian golden hamsters. Repeated intratracheal administrations were made consisting of benzo(a)pyrene in particulate form carried by an inert dust. A high incidence of bronchogenic carcinoma developed. The conditions of exposure to the carcinogen (involving penetration and retention of carcinogenic particles in lung tissues with the dust) are of prime importance in accurately determining the results. Instilling the same carcinogenic particles via other media did not induce lung tumors. The relative importance of identifying carcinogenic materials in air and the conditions of exposure in the origin of lung cancer are discussed.

0184
Schenker, M.B., Weiss, S.T., and Murawski, B.J. (1982) "Health effects of residence in homes with urea formaldehyde foam insulation: a pilot study", Environ. Int., 8:359-363.

KEYWORD: CH2O, health, source, methodology, architecture, home

The 24 full-time residents from six homes with urea-formaldehyde foam insulation underwent standardized allergy, respiratory, and neuropsychiatric tests. Skin testing did not reveal an increased prevalence of sensitivity, atopy, or reaction to 4% formalin. Pulmonary reactions were normal in all subjects. Reported memory problems could not be documented, but 11 of 14 subjects had abnormal tests of attention span; 8 of the 11 had elevated depression scores. Chronic low-level exposure to formaldehyde may cause significant mental changes, but testing of a larger, randomly selected population is necessary.

0406
Schmier, H., and Wicke, A. (1985) "Results from a survey of indoor radon exposures in the Federal Republic of Germany", Sci. Total Environ., 45:307-310.

KEYWORD: dose, outdoor, home, microenvironment, exposure, radon, distribution, foreign, Germany, health, lung

A large-scale radon survey has been carried out in the Federal Republic of Germany. The mean radon concentration was determined with Karlsruhe-type nuclear track dosimeters. Results of measurements in almost 6,000 arbitrarily selected homes are briefly discussed. The radiation dose to the lung from radon and its short-lived daughters contributes considerably to the effective dose equivalent from natural radiation exposure.

0517
Schutte, W.C., Cole, R.S., Frank, C.W., and Long, K.R. (1981) "Problems associated with the use of urea-formaldehyde foam for residential insulation, part III: residential studies in Colorado and Wisconsin", U.S. Department of Energy, Office of Buildings and Community Systems, Washington, DC 20585 (30 pages). NTIS ORNLSUB 75593.

KEYWORD: CH2O, source, energy, field, home, health, architecture, outdoor, weather

The Colorado/Wisconsin residential study was designed as a preliminary study to (1) elucidate the severity and the extent of formaldehyde emission under field conditions, (2) help correlate laboratory findings with field observations, and (3) investigate the cause-and-effect relationship between urea-formaldehyde-foam stability and weather conditions in an area. Samples were collected by the National Institute for Occupational Safety and Health double impinger method using the DuPont 4000 personal sampler pumps and were analyzed by the chromotrophic acid method. Field technicians interviewed occupants to obtain information on the occupants; homes; insulation; odor; eye, throat, and nose irritation; and humidity and temperature in homes and outdoors. Information was also obtained on sky and traffic conditions.

0258
Sciocchetti, G., Scacco, F., Baldassini, P.G., Battella, C., Bovi, M. and Monte, L. (1985) "The Italian national survey of radon exposure", Sci. Total Environ., 45:327-333.

KEYWORD: radon, home, exposure, distribution, source, foreign, Italy, architecture, risk, control

An investigation is being developed to assess the indoor exposure of the Italian population. The survey is organized by statistical areas of sampling to obtain representative samples of houses. The definition of the areas takes into account basic parameters e.g. geolithological environments, radon soil gas from underlying soils and rocks, specific activities of local building materials, climatic and seasonal variations, building technology, types of houses and town planning. The collected data may also be used for the compilation of radon risk maps to plan special monitoring and remedial actions if needed. Preliminary results concerning the above items are discussed.

0540
Scott, A.G. (1983) "The distribution of average radon daughter concentrations in houses estimated from single-sample surveys", Health Phys., 45(2):435-438.

KEYWORD: radon, distribution, sampling, design, exposure, field, literature, foreign, Canada

Single-sample surveys have been used extensively since 1976 to provide rapid estimates of the variation among communities regarding radon and daughter concentrations in an effort to determine the variability of concentrations within a community. These surveys are also useful as a guide to selecting dwellings for further investigation. By the end of 1981, at least 23 surveys of this type will have been completed in Canada.

0646
Scott, A.G., and Findlay, J.G. (July 1983) "Demonstration of remedial techniques against radon in houses on Florida phosphate lands", U.S. EPA, Office of Radiation Programs, Montgomerey, AL 36193 (193 pages). NTIS PB84-156157.

KEYWORD: radon, home, architecture, sampling,QA,control,exposure, source, ventilation, economic

The natural radon content of the soil is elevated in some parts of the Florida phosphate lands, resulting in elevated radon concentrations in the soil gas. If building construction provides routes of entry between the interior of the building and the soil below, then this radon-bearing soil gas may enter the building and elevate indoor levels. This report reviews current building practices and identifies routes of entry. Certain modifications to building practices may reduce indoor radon levels.

0056
Sebben, John, Pimm, Peter, and Shepard, Roy J. (1977) "Cigarette smoking in enclosed public facilities", Arch. Environ. Health, 32(2): 53-57.

KEYWORD: CO, field, study, exposure, smoking, health, ventilation

A portable detector (catalytic electrode) was used to record CO concentrations in enclosed public places. The highest concentrations were found in night clubs, where evening indoor readings ranged from 13.4 ppm, which was 4.1 +/- 1.5 ppm higher than outdoor readings. In one poorly ventilated establishment, values ranged from 20-40 ppm, with substantial gradients around the room. Adequate ventilation and screening of restaurant employees for ischemic heart disease should prevent problems from cigarette CO. Unfortunately, much lower concentrations of other constituents of smoke may cause symptoms and changes of pulmonary function in the nonsmoker. If CO is used as an indicator of cigarette smoke accumulation, concentrations should not exceed ambient readings by more than 5 ppm.

0035
Sega, K., and Fugas, M. (1982) "Personal exposure versus monitoring station data for respirable particulates", Environ. Int., 8:259-263.

KEYWORD: particulate, field, personal, exposure,outdoor,activity, foreign, Yugoslavia

Personal exposure to respirable particulates of 12 subjects working at the same location but living in various parts of Zagreb, Yugoslavia, was monitored for 7 consecutive days and compared with simultaneously obtained data from the outdoor network station nearest to each subject's home. Although personal exposure is related to the outdoor pollution, indoor pollution is also important because the subjects spent, on the average, more than 80% of their total time indoors. The ratio between average personal exposures and respirable particle levels in the outdoor air decreased with the increased outdoor concentration (r = 0.93), indicating that this relationship might serve as a basis for a rough estimate of possible personal exposure.

0355
Sega, K., Fugas, M., Kalinic, N., and Sisovic, A. (1984) "Indoor-outdoor relationships for respirable particles, total suspended particle matter and smoke concentrations in modern office buildings", Environ. Int., 12(1-4):71-74.

KEYWORD: particulate, outdoor, seasonal, smoking, office,foreign, Yugoslavia

Total suspended particulates (TSP), respirable particles (RP), and smoke were measured indoors and outdoors at six sites in five modern office buildings in different parts of a town. Measurements were performed during winter and summer. Correlations between RP, TSP, smoke in RP, and smoke content in TSP were determined for each site, and indoor-outdoor relationships were established for winter and summer.

0770
Seifert, B., Ullrich, D., Mailahn, W., and Nagel, R. (1986) "Fluchtige organische verbindungen in der innenraumluft (volatile organic substances in the indoor air)", Bundesgesundheitsblatt, 29(12):417-424. In German with English summary.

KEYWORD: VOC,home, monitor,alkane,foreign, hydrocarbon, aromatic, field, terpene, outdoor, Germany

Volatile organic compounds (VOC) in the air of West German living spaces were determined for two weeks using passive sampling devices. The surveys conducted, between 1982 and 1985, identified 55 VOCs. Concentrations of linear and branched alkanes, as well as cycloalkanes, aromatics, terpenes, alcohols, chlorinated hydrocarbons, and carbonyl compounds averaged below 50 ug/m3, although 2-week averages of some aromatic and chlorinated hydrocarbons were above 1 mg/m3. Such high concentrations were far beyond those known to occur in outdoor air in traffic.

0442
Seifert, B., and Abraham, H.J. (1983) "Use of passive samplers for the determination of gaseous organic substances in indoor air at low concentration levels", Int. J. Environ. Anal. Chem., 13:237-253.

KEYWORD: exposure, methodology, sampling, VOC, hydrocarbon, QA, laboratory

The design and calibration of a passive sampler operating according to the diffusion principle and its application to analyzing indoor air are described. Taking aliphatic and aromatic hydrocarbons as representative pollutants, researchers demonstrated that, at constant concentration, the amount of substance trapped by the sampler is a linear function of time. An equation is given relating this amount to the mean pollutant concentration. The detection limit is about 300 ug/(m3/hour). For test gas atmospheres, variation coefficients of between 5 and 10% were determined for a 24-hour exposure in an atmosphere with concentrations of the individual hydrocarbons between 150 and 600 ug/m3.

0354
Seifert, B., Drews, M., and Aurand, K. (1984) "Indoor heavy metal exposure of the population around a secondary lead smelter", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 177-182. NTIS PB85-104198.

KEYWORD: Pb, particulate, exposure, metal, methodology, field, Cd, sampling, foreign, Germany

Earlier studies had indicated that the concentration of heavy metals in deposited dust is a much better means of characterizing the exposure of people living close to emission sources than the concentration in suspended particulate matter. Thus, a simple method has been developed in which house dust collected with a passive sampler is used to rapidly screen the heavy metal content of dust deposited in houses located near sources. Analyzing such dust samples for Pb and Cd permitted detecting the most polluted spots in an area surrounding a secondary lead smelter at Oker, Federal Republic of Germany. The method, as well as the results of field measurements carried out in 1982, is discussed.

0262
Seifert, B., and Abraham, H.J. (1982) "Indoor air concentrations of benzene and some other aromatic hydrocarbons", Ecotoxicol. Environ. Safety, 6:190-192.

KEYWORD: benzene, aromatic, source, combustion, smoking, field, sampling, exposure

Reasons for the presence of contaminants in indoor environments include frequent burning processes such as smoking, use of consumer products, and emanation from building materials. Indoor concentrations of benzene and other aromatic hydrocarbons were studied. Sampling was conducted with a passive sampler and charcoal pad.

0439
Sem, G.J., and Tsurubayashi, K. (1975) "A new mass sensor for respirable dust measurement", Am. Ind. Hyg. Assoc. J., 36:791-800.

KEYWORD: particulate, methodology, personal, exposure, monitor, smoke, aerosol, QA

A new portable instrument measures mass concentration in the 100 ug/m3 range of airborne dust particles smaller than 10 um. An electrostatic precipitator deposits particles as small as 0.01 um onto a piezoelectric microbalance sensor. The instrument gives digital readouts and has a built-in sensor cleaner.

0148
Settergren, S.K., Hartwell, T.D., and Clayton, C.A. (Aug. 1984) "Study of carbon monoxide exposure of residents of Washington,

D.C. -- additional analysis", Contract no. 68-02-3679, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (59 pages). Not available from NTIS.

KEYWORD: CO, personal, exposure, monitor, microenvironment,EPA$, vehicle, interior, activity, home

This report presents additional analyses of personal CO data obtained in the winter of 1982-83 from a sample of Washington, DC, metropolitan area nonsmoking and noninstitutionalized people aged 18 to 70 years. The analyses cover 8-hour (and 1-hour) maximum CO exposures and how these exposure levels may be affected by ambient CO levels and by the home, work, and travel characteristics respondents reported in the study questionnaire. Little relationship was detected between 8-hour maxima and home characteristics, whereas some work and travel characteristics do seem to affect CO levels. The analyses also investigate how total population CO exposure and time vary among four major environments -- in transit, indoors-residence, indoors-other, and outdoors. Indoors-residence accounted for over 50% of total CO exposure. However, the in-transit environment showed, by far, the highest CO exposure. Consequently, the total exposure and time of this environment were further partitioned by mode of travel. More detailed analyses are planned.

0779
Sexton, K., Petreas, M.X., Liu, K.S., and Kulasingam, G.C. (1985), "Formaldehyde concentrations measured in California mobile homes", Paper No.85-85.2, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (20 pages).

KEYWORD: CH2O, health, activity, personal, monitoring, seasonal, risk, field, architecture, home, source, demographic

In 1984, the Indoor Air Quality Program of the California Department of Health Services undertook a project to measure average formaldehyde (CH2O) concentrations inside mobile homes. Because CH2O emissions from building materials decrease over time, an age-stratified random sample (i.e., 60% of mobile homes less than or equal to 3 years old) was obtained from existing records. Week-long CH2O concentrations were measured inside more than 600 mobile homes while occupants continued with normal activities. Most residences were monitored during summer and winter to examine seasonal effects. In addition, data on occupant and housing characteristics as well as occupant activities during sampling were collected by means of a self-administered questionnaire. Average CH2O concentrations inside mobile homes (< 10 years old) are in the range of 0.07 ppm - 0.13 ppm and decrease gradually with age. Determining the health significance of these exposures is a prerequisite for realistic assessment of related public health risks.

0084
Sexton, K., Treitman, R.D., Spengler, J.D., and Turner, W.A. (Aug. 1984) "The effects of residential wood combustion on indoor and outdoor air quality: a case in Waterbury, Vermont", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 111-116. NTIS PB85-104214.

KEYWORD: field, particulate, exposure, outdoor, wood, combustion, PAH, carbon, home

Findings from a wood-burning study in Waterbury, VT, are presented. The air monitoring program, conducted from January to March 1982, emphasized measurements of total, inhalable, and respirable particulates. Indoor and outdoor data on respirable particles were obtained for 24 private residences, 19 with wood-burning appliances. Personal exposure to respirable particles was investigated by having 48 nonsmoking volunteers carry personal sampling pumps for 7 days. Selected particulate samples were analyzed for elemental composition, polycyclic aromatic hydrocarbons, and organic and elemental carbon. Data are presented comparing chemical and elemental concentrations between indoor and outdoor environments.

0216
Sexton, K., Webber, L., Hayward, S.B., and Sextro, R.G. (1984) "Characterization of particle composition, organic vapor constituents, and mutagenicity of indoor air pollutant emissions", Report no. CA/DOH/AIHL/R-289, California Department of Health Services, Berkeley, CA 94704 (26 pages).

KEYWORD: multipollutant,particulate,source,smoking, mutagenicity, VOC, laboratory, appliance

A joint chamber experiment was carried out by the California Indoor Air Quality Program and the Lawrence Berkeley Laboratory to characterize particle and vapor emissions from several important indoor sources, including a gas range, tobacco smoking, frying hamburger, a kerosene heater, and selected aerosol spray products. Among the emissions data collected for each source were particle size distributions, particle-phase elemental and chemical compositions, volatile compound identification, and mutagenicity of particles and vapor-phase constituents. Findings were used to assess qualitatively the nature of airborne emissions from each source and to compare emission constituents among source categories. This approach is a necessary first step in evaluating the feasibility of developing unique signatures for individual sources using a broad array of emission characteristics.

0407
Sexton, K., et al. (1984) "Winter air quality in a wood-burning community: a case study in Waterbury, Vermont", Atmos. Environ., 18(7):1357-1370.

KEYWORD: wood, outdoor, particulate, combustion, field, exposure, regulation, weather, source, home

The recent upsurge in residential wood combustion has raised questions about potential adverse effects on ambient air quality and public health. Before policymakers can make informed and rational decisions about the need for government intervention, more information is needed concerning the nature and extent of the problem. This paper presents findings from the 1982 Harvard Wood-Burning Study in Waterbury, VT. Waterbury, a rural community of about 2,000 people, was an ideal location for this investigation because (1) half of the private residences are heated with wood fuel, (2) frequent winter temperature inversions promote pollution buildup in the valley, (3) there are no major industrial sources, and (4) the Vermont Agency of Environmental Conservation has compiled a detailed wood-burning inventory. The ambient air monitoring study, from January to March 1982, emphasized measurements of total, inhalable, and respirable particulate matter. Results indicate that 60 to 70% of the Waterbury aerosol was composed of particles less than 2.5 um. A combination of indirect evidence suggests that wood burning was the major source of airborne particles in residential sections of the town. Dramatic diurnal variations in particulate concentrations were observed, with peak values at night exceeding afternoon levels by 5 to 10 fold. Both meteorology and emission patterns contributed to observed fluctuations.

0212
Sexton, Ken (1985) "A survey of indoor air monitoring services: is there a private demand for healthful indoor air quality?", J. Air Pollut. Control Assoc., 35(6):626-631.

KEYWORD: CH2O, radon, asbestos, home, VOC, ventilation, exposure, monitor, economic, methodology

A questionnaire on private indoor air monitoring services was returned by 43 companies that had responded to ads in four major air pollution journals. Most of the companies also participate in ambient and industrial air quality research. They tend to employ a wide range of analytical and health professionals and will measure a wide range of parameters. Costs to homeowners are likely to exceed $100 per parameter for measurements of formaldehyde, radon, asbestos, volatile organic chemicals, and air exchange rates. Demand for these services is increasing.

0218
Sexton, Ken, Letz, Richard, and Spengler, John D. (1983) "Estimating human exposure to nitrogen dioxide: an indoor/outdoor modeling approach", Environ. Res., 32:151-166.

KEYWORD: NO2, source,model,activity, outdoor, personal, exposure, ventilation, appliance, home

A simple deterministic model is developed in an attempt to provide a more realistic estimate of NO2 exposures. The model relates exposure to background ambient levels, indoor values, and human activities. Ambient and indoor parameters are derived from monitoring programs in six U.S. cities. Results suggest NO2 concentrations in private dwellings vary primarily with outdoor levels and type of cooking fuel, but are also affected by factors such as air-exchange rates and strength of indoor sources. Estimates of population exposures are obtained by combining observed NO2 distributions from outdoor and indoor settings with information about number of people and time spent in each microenvironment.

0213
Sexton, Ken, Liu, Kai-Shen, and Petreas, Myrto X. (1986) "Formaldehyde concentrations inside private residences: a mail-out approach to indoor air monitoring", J. Air Pollut. Control Assoc. 36(6):698-704.

KEYWORD: CH2O, home, sampling, methodology, QA, exposure, field

During 1984, the California Indoor Air Quality Program undertook two studies, summer and winter, aimed at evaluating the feasibility of mailing out passive monitors to measure formaldehyde (CH2O) concentrations inside a large sample of private residences. A pilot study in 51 nonmanufactured dwellings preceeded an indoor CH2O survey in more than 500 mobile homes throughout California. Each investigation was carried out entirely by mail, including solicitation of volunteers, placement and recovery of monitors, collection of data on occupant and housing characteristics, and communication of test results. Data, data quality, and the method's feasibility are discussed.

0198
Sexton, Ken, Spengler, John D., and Treitman, Robert D. (1984) "Effects of residential wood combustion on indoor air quality: a case study in Waterbury, Vermont", Atmos. Environ., 18(7):1371-1383.

KEYWORD: particulate, EPA$, wood, outdoor,field,combustion, home, ventilation, model, exposure

An indoor/outdoor monitoring study was conducted from January to March 1982 in Waterbury, VT. Respirable particle measurements were made inside and outside 24 homes (all occupants were nonsmokers), 19 with wood-burning appliances and 5 without. Data were also obtained on seasonal air-exchange rate, heating fuel consumption, and relevant home characteristics. Indoor particle levels were consistently higher than outdoor levels regardless of heating-fuel type. No statistical difference was observed between 24-hour average respirable particle levels in wood- and nonwood-burning homes. A linear regression model, incorporating information on air-exchange rate, house volume, fuel use, and outdoor level, accounted for about 20% of the variance in indoor particle concentrations.

0204
Sexton, Ken, and Ryan, Barry P. (1986) "Assessment of human exposure to air pollution: methods, measurements and models", Watson, A., Bates, R.R., and Kennedy, D., Eds., "Air pollution, the automobile, and public health", National Academy of Sciences Press, Washington, DC (86 pages).

KEYWORD: literature, exposure, research, methodology, model, personal, monitor, biomonitoring, outdoor

This chapter reviews the history, terminology, and methodology of exposure assessment. Direct and indirect ambient air, biological (blood, urine, tissue), and personal monitoring are explained. Statistical, physical, and stochastic modeling are described. Research recommendations are made. The bibliography is extensive.

0623
Sexton, Ken, and Wesolowski, Jerome, J. (1985) "Safeguarding indoor air quality", Environ. Sci. Technol., 19(4):305-309.

KEYWORD: epidemiology, literature, microenvironment, home, risk, industrial, control, office, multipollutant, health, outdoor

California is the first state to implement a program devoted exclusively to the investigation of nonindustrial indoor air quality. Discussed are general impediments to enacting such a program, justification for action, California's indoor air quality program, priorities, state interagency coordination, and complex policy issues. The goal of the program is to define the components of healthful indoor air, to evaluate the applicability of available mititgating measures, and to assess the relative merit of policy alternatives.

0217
Sexton, K., Liu, K. S., Treitman, R.D., Spengler, J.D., and Turner, W.A. (1986) "Characterization of indoor air quality in wood-burning residences", Environ. Int. 12(1-4):265-278.

KEYWORD: particulate, home,PAH, field, wood, combustion, carbon, outdoor, EPA$, exposure, outdoor

Findings from a residential wood-burning study in Waterbury, VT, are presented, with indoor/outdoor comparisons of particle mass, size distribution, and composition. Elemental composition and concentrations of polyaromatic hydrocarbons and carbon suggest that significant differences exist between indoor and outdoor environments in six homes, with indoor values exceeding outdoor values for many airborne constituents. Various indoor sources besides wood smoke contributed to the indoor pollutant levels.

0288
Sexton, K., Liu, Kai-Shen, Hayward, S.B., and Spengler, J.D. (1985) "Characterization and source apportionment of wintertime aerosol in a wood-burning community", Atmos. Environ. 19(8):1225-1236.

KEYWORD: particulate, PAH, carbon, weather,methodology, source, wood, outdoor, combustion, EPA$,field,home,exposure

The continuing upsurge in residential wood combustion has raised questions about potential adverse effects on ambient air quality. A study to investigate the effects of wood-burning emissions on ambient aerosol concentrations was conducted in Waterbury, VT, from January to March 1982. Data on total, inhalable and respirable particles (24-hour averages) were collected at a central monitoring site and augmented with similar measurements at two auxiliary stations. Mass concentrations were determined gravimetrically and selected samples were analyzed for elemental composition, polycyclic aromatic hydrocarbons, and organic and elemental carbon. In addition, continuous data from an integrating nephelometer and a meteorological data acquisition system were collected at the central site. This paper presents results of organic and elemental characterization of wintertime aerosol and examines several source-apportionment methods, focusing on the contribution of residential wood combustion to measured ambient concentrations.

0771
Sexton, K., Liu, K., Hayward, S.B., and Spengler, J.D. (1984) "Organic and elemental characterization of winter-time aerosol in a wood-burning community", Paper no. 84-80.2, presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (17 pages).

KEYWORD: combustion, wood, home, field, source, outdoor, K, Fe, carbon, particulate, PAH, SO4, CO, exposure

Concerns about rising prices and uncertain availability of petroleum and natural gas have led to increased use of alternative fuels for residential space heating. Sales of woodstoves have increased 10-fold since 1972, and approximately 10% of the total U.S. space heating input is from wood. Woodburning stoves, furnaces, and fireplaces have been shown to emit significant quantities of particles, CO, and organic compounds, including polycyclic aromatic hydrocarbons (PAH). Ambient air monitoring programs have shown that residential wood combustion (RWC) is a significant source of winter aerosols in many communities. To examine the effects of RWC on outdoor, indoor, and personal exposure to particulate matter, an intensive air monitoring program was undertaken in Waterbury, VT during January - March 1982. This paper discusses elemental and organic characteristics of outdoor respirable particulate (RSP) samples, focusing on the contribution of RWC to observed concentrations. Particulate carbon accounts for > 50% of the winter RSP mass measured, with sulfate (primarily SO4) accounting for no more than 25%. Elevated K/Fe ratios and high organic carbon content of RSP were consistent with expected impacts from RWC. Measured PAH values were similar to winter values in other New England communities and were likely to result from local sources (primarily RWC). Overall, results of the study suggest that RWC has a substantial impact on winter aerosol concentrations in Waterbury, VT.

0775
Sexton, K., and Wesolowski, J.J. (1984) "California's indoor air quality program", Paper no. 84-35.6 presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, (13 pages).

KEYWORD: health, risk, field, multipollutant, exposure, control, ventilation, regulation, source, home, office, activity

The concerns about nonindustrial indoor air pollution are summarized and the California Indoor Air Program is outlined. Included are discussions of time spent indoors, concentration buildup in confined spaces, energy efficiency measures/ventilation, and research that shows ambient measurements do not adequately reflect personal exposures. Six impediments to action are discussed: (1) understanding of the problem is inadequate, (2) no lobbying constituency has developed, (3) no Federal body has clear-cut statutory authority, (4) Federal research funding is inadequate, (5) delicate policy issues remain (proper government role in private buildings), and (6) concern that the case for ambient air standards will be weakened by heightened attention to indoor air. Justifications for the California indoor air research program include growing evidence of health risk and California's leadership in other environmental and public health issues. The legislative process which resulted in California's program is described. The program is structured to obtain relevant information about emission sources, ventilation, concentrations, human activity patterns, exposures, health risks, control measures, and public policy options. Research activities include field studies in residences and office buildings, as well as laboratory studies.

0774
Sexton, Ken (1985) "Indoor air quality: an overview of policy and regulatory issues", paper no. 85-46.1, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (23 pages).

KEYWORD: regulation, multipollutant, source, exposure, control, research, methodology, health, risk

This overview of nonindustrial indoor air pollution issues focuses on policy and regulation and includes discussion of time spent indoors, concentration buildup in confined spaces, energy efficiency measures/ventilation, complex consumer materials, complex activities, and complaints of inadequate indoor air quality. Problems are defined--source identification, measurement of contamination, and health risk analysis--before mitigating measures are discussed. The complex policy issues are reviewed and a number of important questions identified, primarily those concerning government (Federal, state, local) authority to intervene in private buildings and residences. The strengths and weaknesses of potential government responses are reviewed. These include (1) no action, (2) more research, (3) public education, (4) economic incentives, (5) moral suasion, and (6) definition of legal liability standards. The responsibilities of and precedents set by EPA and the Occupational Safety and Health Administration are noted. The National Ambient Air Quality Standards could serve as a model for indoor air standards. The author suggests that the Clean Air Act be amended to include indoor air. Existing statutory authority and government activity at all levels are outlined.

0425
Sexton, Ken (1986) "Indoor air quality: an overview of policy and regulatory issues", Sci. Technol. Human Values, 11(1):53-67.

KEYWORD: health, risk, control, regulation, multipollutant, methodology, research, source, exposure

Evidence is increasingly showing elevated concentrations of many air pollutants in private and public buildings. Among these airborne contaminants are tobacco smoke, CH2O, CO, NO2, radon decay products, asbestos fibers, respirable particles, volatile organic compounds, bacteria, viruses, fungi, and aeroallergens. The potential hazards of indoor air pollution have only recently attracted widespread attention. However, few data are available for evaluating health risks for most contaminants. The need to safeguard indoor air quality is discussed, as well as the topics of indoor air quality problem definition, health risks, mitigation measures, policy issues, and government response. Regulatory issues and existing statutory authority and government activity are also discussed.

0078
Sexton, Ken, Spengler, John D., and Treitman, Robert D. (1984) "Personal exposure to respirable particles: a case study in Waterbury, Vermont", Atmos. Environ. 18(7):1385-1398.

KEYWORD: particulate, smoking,outdoor, model, exposure, personal, statistical, monitor, microenvironment, activity

A study to assess personal exposure of 48 nonsmoking volunteers to respirable particles was conducted from January to March 1982 in Waterbury, VT. The volunteers carried Harvard University/Electric Power Research Institute personal samplers every other day for 2 weeks. Simultaneous measurements with similar monitors were made inside and outside each participant's home. Findings indicate that outdoor (ambient) particle levels were not an important determinant of personal exposure, while in-home concentrations accounted for 25% to 30% of the variation in personal values. A linear regression technique was used to estimate respirable particle concentrations in three microenvironments where measurements were not available. These values were combined with data on timed activities and observed outdoor and indoor concentrations to construct a simple time-weighted exposure model. Predicted exposure using this approach agreed well with measured values. However, the validity and suitability of estimated coefficients for applications to other communities and different times of year have not been established.

0099
Sexton, Ken, Webber, L.M., Hayward, S.B., and Sextro, R.G. (1986) "Characterization of particle composition, organic vapor constituents, and mutagenicity of indoor air pollutant emissions", Environ. Int., 12(1-4):351-362.

KEYWORD: multipollutant, particulate, mutagenicity, exposure, source, laboratory, VOC, smoking, appliance

As understanding of human exposure to air pollutants improves, it is becoming increasingly evident that indoor environments play a critical role in determining exposures. However, it is not possible at this time to establish the relative contribution of indoor and outdoor sources to personal exposures, nor can the contribution of specific indoor emissions be quantified. To address these issues, a chamber experiment was initiated to measure particulate and organic emissions from important indoor sources. Data on particle size distributions, morphology, mutagenicity, and elemental and chemical composition, as well as information about volatile organic emissions, were collected for each source. Results of the study will be used to determine the feasibility of using source-receptor techniques to apportion indoor sources.

0128
Sexton, Ken, and Hayward, Steven B. (1987) "Source apportionment of indoor air pollution", Atmos. Environ., 21:407-418.

KEYWORD: source, model, exposure, monitoring, outdoor, literature

An understanding of the relative contributions from important pollutant sources to human exposures is necessary for the design and implementation of effective control strategies. Exposures to elevated pollutant concentrations often occur as a result of indoor, rather than outdoor, emissions. While the major indoor sources have been identified, their relative impacts on indoor air quality have not been well defined. Application of existing source-apportionment models to nonindustrial indoor environments is only just beginning. These models might be used to distinguish between indoor and outdoor emissions, as well as to distinguish among indoor sources themselves. However, before the feasibility and suitability of source-apportionment methods for indoor applications can be assessed adequately, model assumptions and associated data requirements must be considered.

0156
Sexton, Ken, and Repetto, Robert (1982) "Indoor air pollution and public policy", Environ. Int., 8:5-10.

KEYWORD: policy, exposure, regulation, economic, control, method

Although scientific interest in the problem of indoor air pollution continues to grow, efforts to measure indoor pollutant concentrations, define exposure levels, and estimate health risks remain in their infancy. Policymakers must deal with the question of how best to protect public health and safety in the face of incomplete and often contradictory information. In the past, official response to environmental pollution has traditionally taken the form of "control by regulation". However, creation of a regulatory framework for indoor air quality poses special policy issues that suggest the need to explore alternative modes of intervention. Promulgation of indoor air quality standards and other regulations must confront the fact that individuals are already making decisions about their own air quality. Regulations may or may not improve these decisions. Among the logical and relatively inexpensive modes of intervention are public information programs, development of simple warning devices, and product testing and labeling.

0482
Sextro, R. G., Offermann, F. J., Nazaroff, W. W., Nero, A. V., Revzan, K. L., and Yater, J. (1986) "Evaluation of indoor aerosol control devices and their effects on radon progeny concentrations", Environ. Int., 12(1-4):429-438.

KEYWORD: EPA$, laboratory, dose, radon, particulate, smoking, control, exposure

Eleven portable air cleaning devices were evaluated for control of indoor concentrations of respirable particles and their concomittant effects on concentrations of radon progeny. Following injection of cigarette smoke and radon into a room-size chamber, decay rates for particles and radon progeny concentrations were measured with and without air cleaner operation. Particle concentrations were obtained for total number concentration and for number concentration by particle size. In tests with no air cleaner, the natural decay rate for cigarette smoke was observed to be 0.2/hr. Air cleaning rates for particles were found to be negligible for several small panel-filters, a residential ion-generator, and a pair of mixing fans. The electrostatic precipitators and extended surface filters tested had significant particle removal rates, and a high efficiency particle air-type filter was the most effective air cleaner. The evaluation of radon progeny control produced similar results; the air cleaners which were effective in removing particles were also effective in removing radon progeny. At low particle concentrations, precipitation of the unattached radon progeny onto room surfaces (plateout) is an important removal mechanism. The plateout rate for unattached progeny was 15/hr. The unattached fraction and the overall removal rate due to deposition of attached and unattached nuclides have been estimated for each radon decay product as a function of particle concentration. Air cleaning reduces total radon progeny. However, the relative alpha decay dose to the lungs appears to change little as the particle concentration decreases because of the greater radiological importance of the unattached progeny.

0593
Sheldon, L.S., Sparacino, C.M., and Pellizzari, E.D. (1985) "Review of analytical methods for volatile organic compounds in the indoor environment", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 335-349.

KEYWORD: methodology, literature, personal, exposure, QA, VOC, monitor, sampling

Successful methods for analyzing volatile organics in the indoor environment must fulfill several criteria: (1) they must be capable of detecting pollutants at ambient levels (i.e., ppt-ppb); (2) collection and measuring devices must be lightweight, compact, and quiet; (3) such devices should be easy to calibrate and use in the field; and (4) measuring devices should provide accurate and reproducible analysis, with minimal artifact and contamination problems. A number of devices that have been laboratory or field tested (or both) have been developed to meet these criteria. Monitors can be classified into two general categories: (1) continuous devices, which measure pollutants on the spot, and (2) integrating devices, which collect the pollutant for later analysis. These two types of devices may be further divided into (1) active monitors, which use a pump to pull air across a sensor or collector, and (2) passive devices, which rely on diffusion to bring the pollutants into contact with the sensor or collector. The analytical performance of each of the currently available methods is reviewed. Instrumentation detection limits, sensitivity, interferences, precision, and accuracy are discussed.

0538
Shleien, B., Wall, M.A., and Lutz, David (1968) "Estimation of radiation doses to the respiratory tract from inhalation of airborne radioactivity", Environ. Sci. Tech., 26:438-443.

KEYWORD: radon, dose, health, sampling, model, lung, radiation, particulate, exposure, outdoor,

A "graded filtration" sampler developed to estimate the respiratory deposition of airborne fallout provides information that, when used with a suitable lung model, permits estimation of the radiation dose to the nasopharyngeal, tracheobronchial, and pulmonary regions of the adult respiratory tract. Estimated doses to adults from airborne fallout collected in November 1966 and January 1967 were 85 and 130 microrem per 70 years to the nasopharyngeal and pulmonary regions respectively. Estimated radiation dose to the tracheobronchial region was less than 0.01 microrem per 70 years. A dose of 225 microrem per 70 years to the thyroid gland was estimated to result from inhalation. The greatest single dose from fresh fission products was to the respiratory lymphatic nodes as a result of inhaled cerium-144 and praseodymium-144. This was approximately 40 times the pulmonary region dose. Among long-lived radionuclides, plutonium-239 delivered the greatest dose to the respiratory lymph nodes. Doses to the respiratory tract from the levels of airborne fresh fission products encountered in this study are low when compared with nonoccupational radiation doses due to inhaled radon and its short-lived daughters. This approach to estimating respiratory doses is applicable to nuclear facility monitoring for airborne particulates.

0659
Shy, Carl M., Kleinbaum, David G., and Morganstern, Harold (1978) "The effect of misclassification of exposure status in epidemiological studies of air pollution health effects", Bull. N. Y. Acad. Med., 54(11):1155-1165.

KEYWORD: exposure, methodology, monitoring, risk, health, model, design, statistical, monitor, personal

This paper emphasizes the potential for misclassification of exposure status in most epidemiologic studies of air pollution health effects and suggests some remedies. Differences in residences, workplace environment, and physical activity contribute to personal exposures that cannot be monitored by fixed stations. Painstaking efforts are needed to assess personal exposures to pollutants in a representative sample of diseased and nondiseased persons. The results could be compared with routine monitoring methods and measures of sensitivity and specificity could be deduced. Statistical corrections could then be made to reduce the misclassification of exposure.

0012
Silverman, F., Corey, P., Mintz, S., Oliver, P., and Hosein, R. (1982) "A study of effects of ambient urban air pollution using personal samplers: a preliminary report", Environ. Int., 8:311-316.

KEYWORD: NO2, SO2, particulate,field,personal, exposure, monitor, EPA$, health, lung, foreign, Canada, outdoor

Air pollution has been associated with an increased incidence of respiratory disease. However, significant differences may exist between air pollution levels measured at conventional fixed monitoring stations and actual levels inhaled by a subject. Furthermore, studies of effects of air pollution are assessed by symptom and medication diaries and simple pulmonary function tests. In this study subjects carried a small portable air sampler for particulates, SO2, and NO2. Levels are compared to data obtained from the same type of sampler located at a fixed monitoring station. Preliminary analysis shows that the levels of the three pollutants are low, and there are significant differences among them. Change in pulmonary function during the day correlated only with personal NO2 measurements. This suggests the need for estimating air pollution exposure using personal samplers when investigating health effects.

0089
Silverman, F., Corey, P., Mintz, S., and Hosien, M.R. (Aug. 1984) "Factors that influence assessments of health effects of air pollution", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 123-137. NTIS PB85-104214.

KEYWORD: NO2, SO2, particulate, personal,exposure,health,outdoor, methodology, seasonal, activity, lung, foreign, Canada

The report illustrates the influences of method of analysis, estimates of exposure, subject type, and seasons of the year on the health effects of air pollution. Small portable multipollutant samplers for NO2, SO2, and particulate matter were carried by asthmatics and nonasthmatics and placed at a downtown Toronto, Canada, air pollution monitoring station. Each subject was visited for up to 20 days; pulmonary function was assessed (by spirometry) in the morning when sampling began and at the end of the day when sampling ended. A questionnaire was completed documenting symptoms, medications, daily activities, and exposure to potential irritants.

0463
Sinclair, J.D., Psota-Kelty, L.A., and Weschler, C.J. (1985) "Indoor/outdoor concentrations and indoor surface accumulations of ionic substances", Atmos. Environ., 19(2):315-323.

KEYWORD: ion, particulate, office, indoor, aerosol, Al, NH4, SO4, source, model, Ca, NO3, Cl, K, outdoor, Zn

The airborne concentrations of soluble ions in fine and coarse particles were measured indoors and outdoors at telephone offices in Wichita, KS, and Lubbock, TX. These concentrations were compared with the mean annual indoor surface accumulations of these ions on Zn and Al structural surfaces. On average, the major soluble ions contained in fine airborne particles are NH4, SO4, and NO3; coarse particles contained Ca and NO3. K and chloride have indoor/outdoor ratios that are larger in fine particles than those observed for the other ionic species, indicating the existence of a significant indoor source. Similar comparisons in coarse particles show that Na, chloride, and sometimes SO4 have significant indoor sources. For chloride, a simple model was used for apportioning surface accumulation at each location due to corrosive chlorine gases, coarse particles, and fine particles. For other ions where corrosive gases are not important, the accumulation has been apportioned between coarse and fine particles. From these data, experimental deposition velocities for fine-mode SO4 ions and coarse-mode Ca ions were calculated to be 0.003 and 1.0 cm per second, respectively, at Wichita, while those at Lubbock were 0.005 and 0.2 cm per second.

0046
Sinclair, J.D., and Psota-Kelty, L.A. (1985) "Indoor/outdoor concentrations and indoor surface accumulations of ionic substances", Atmos. Environ., 19(2):315-323.

KEYWORD: particulate,outdoor,ion, source, model, NH4, SO4, NO3, Ca, K, office, aerosol, Al, Zn, Cl

The airborne concentrations of soluble ions in fine particles and coarse particles have been measured indoors and outdoors at telephone offices in Wichita, KS, and Lubbock, TX. These concentrations are compared with the mean annual indoor surface accumulations of these ions on zinc and aluminum structural surfaces. On average, the major soluble ions contained in fine airborne particles are ammonium, sulfate, and nitrate, while those contained in coarse particles are calcium and nitrate. In the fine mode, potassium and chloride have indoor/outdoor ratios that are larger than those observed for the other ionic species, indicating the existence of a significant indoor source. In the coarse mode, similar comparisons show that sodium, chloride, and sometimes sulfate have significant indoor sources.

0523
Singh, J., Walcott, R., and St. Pierre, C. (1982) "Evaluation of the relationship between formaldehyde emissions from particleboard mobile home decking and hardwood plywood wall paneling in experimental mobile homes", U.S. Department of Housing and Urban Development, Washington, DC 20410 (81 pages). NTIS PB83-237404.

KEYWORD: CH2O, methodology, field, monitoring, exposure, home, regulation, source, control, architecture

To evaluate the impact of reduced formaldehyde-emitting hardwood plywood paneling and particleboard decking used in mobile homes, the U.S. Department of Housing and Urban Development and several building supply associations cooperatively designed and implemented a program of testing and research. The study called for construction of four test homes--two using plywood paneling and particleboard decking thought to have a low potential to emit formaldehyde, and two using materials thought to have higher emitting potentials. The relationship between the formaldehyde levels produced in the mobile homes and the formaldehyde potential was evaluated by monitoring the mobile homes weekly and by carefully testing the wood products using desiccator and chamber test methods. The two homes built of lower emitting materials showed consistently lower formaldehyde levels, averaging slightly less than half the levels measured in the higher emitting homes. Testing the emission potential of formaldehyde in the wood products using the desiccator and chamber methods showed clear and major differences between the emission potential of the products. Researchers felt that the proposed Hardwood Manufactures Association product guidelines were inadequate in meeting target formaldehyde levels of 0.4 to 0.5 ppm. In addition, a much more rigorous test method for any product standard was necessary.

0648
Sisovic, A., and Fugas, M. (1985) "Indoor concentrations of carbon monoxide in selected urban microenvironments", Environ. Monit. Assess., 5:199-204.

KEYWORD: school, CO, seasonal, outdoor, vehicle, monitor, field, microenvironment, foreign, Yugoslavia

CO concentrations were measured in Yugoslavia in five kindergartens, one children's hospital, and two homes for aged for 10 random days in winter and 10 in summer. All had practically no indoor sources, and all were in the city center. Indoor CO concentrations were the result of (1) distance from and traffic density in the nearest street, (2) general pollution level, (3) seasonal differences, day-to-day variations, and daily cycle of air pollution, and (4) the location of traffic having a dominant influence. Therefore, locating institutions for sensitive population groups in old city centers within a block of houses seems to be a suitable solution to reducing CO exposures.

0577
Skaaret, Eimund (1986) "Contaminant removal performance in terms of ventilation effectiveness", Environ. Int., 12(1-4):419-427.

KEYWORD: laboratory, multipollutant, NO2, model, control, NOx, ventilation, statistical, foreign, Norway, Sweden

Substantial work on ventilation effectiveness has been carried out, both in Norway and Sweden, using tracer gas techniques based on fundamental physical and mathematical concepts. At present, the nature of and how to characterize (using tracer gas techniques) the flow of ventilation air and contaminants through a ventilated room are known. This study shows that age-analyzing techniques are an excellent tool to assess ventilation effectiveness. It is important to distinguish between "air-exchange efficiency" and "contaminant-removal effectiveness." Only when a source is homogenous and passive are the age of air and contaminants in a room equal. However, the air-exchange efficiency accounts for the effective removal of contaminants remaining in the room after the generation stops. Displacement flow has proved to be the best flow principle in ventilation, and the ventilation air, in general, should be supplied to the zone of occupation. The design procedure shall, among other things, contain a contaminant source analysis to design the ventilating system to create the most favorable flow patterns for the contaminants.

0195
Skaret, Eimund, and Mathisen, Hans Martin (1982) "Ventilation efficiency", Environ. Int., 8:473-481.

KEYWORD: model, ventilation, laboratory, foreign, Norway, energy

Research in Norway indicated that ventilating systems can be designed for higher ventilation efficiency in the zone of occupation than systems designed for complete mixing. Expressions for ventilation efficiency are derived using a two-box theoretic model. These definitions of ventilation efficiency can be used for practical measurements, and also seem to be valid for multibox schemes. Measurements reviewed show that diagonal schemes are the most efficient. Short-circuiting schemes, with warm air supply along the ceiling and high wall exhaust, produce very low efficiencies. The mathematical model predicts high efficiencies using diffuse air supply directly to the zone of occupation, if the air is not used for heating.

0205
Smith, Kirk R. (1984) "Indoor air: a view from developing countries", Environ. Sci. Technol., 18(b):271A.

KEYWORD: CO, source, particulate, hydrocarbon, rural, exposure, combustion, biomass, foreign

Contrary to Western research assumptions, the most important exposures to many pollutants may be to rural women in developing countries where biomass is the principal fuel. Cooking indoors with open biomass fires is still the most frequent technique in the world, and the smoky air that results contains high concentrations of CO, particulates, and hydrocarbons. The few hard data available support this view. Reduction of this exposure is technically and economically feasible.

0245
Smith, Kirk R., et al. (1983) "Air pollution and rural biomass fuels in developing countries: a pilot village study in India and implications for research and policy", Atmos. Environ., 17(11):2343-2362.

KEYWORD: personal, exposure,particulate, foreign,source,emission, benzo-a-pyrene,activity,India,biomass,combustion,rural,research

Personal exposures to total suspended particulates and benzo-a-pyrene in four rural Indian villages were measured in 1981. Pollutant levels were measured indoors as a function of biomass fuel and type of cooking stove used. Various cooking times, family sizes, and income levels were considered. Particulate exposures averaged nearly 7 mg/m3 and benzo-a-pyrene about 400 ng/m3 during the cooking period, which occupied about 10% of the year. Factors affecting indoor air pollution exposures in rural areas of developing nations are discussed with reference to published field data. The paucity of related information reveals many issues requiring future research, including fuel use, combustion conditions, and pollutant emission rates.

0264
Smith, Lawrence R. (Sept. 1981) "Nitrosamines in vehicle interiors", U.S. EPA, Emission Control Technology Division, Ann Arbor, MI 48105 (71 pages). NTIS PB82-125014.

KEYWORD: nitrosamine, sampling, vehicle, interior, literature, methodology, microenvironment, exposure

Views of researchers concerning the triethanolamine analyzer and the thermosorb air samplers for nitrosamines are presented. Gas samples were taken from within 58 vehicles to determine the effects of age, mode of operation, and ambient conditions on interior nitrosamine levels. Occupant exposure levels were estimated using test vehicle data.

0464
Smith, K.R., Aggarwal, A.L., and Dave, R.M. (1983) "Air pollution and rural biomass fuels in developing countries: a pilot village study in India and implications for research and policy", Atmos. Environ., 17(11):2343-2362.

KEYWORD: rural, research, field, personal, exposure, CO, indoor, benzo-a-pyrene,source,biomass,foreign,wood,particulate,India

In four Indian villages, researchers studied personal exposure to total suspended particulates (TSP) and particulate benzo-a-pyrene (BaP) of women cooking on simple stoves using traditional biomass fuels. Study results are presented together with socioeconomic and fuel-use determinations. TSP exposures averaged nearly 7 mg/m3 and BaP about 4,000 ng/m3 during the cooking period, which occupied 10% of the women's time. The factors affecting indoor air pollution exposures in rural areas of developing countries are categorized and discussed by reference to the few published field measurements. Comparisons are made with other common exposures in urban and occupational settings. The sparse information indicates that rural exposures are relatively high. Subjects for future research are outlined and general policy implications mentioned.

0276
Snee, R.D., Bailey, S.P., Fellner, W.H., and Pfeiffer, C.G. (1985) "Variation in the relationship between blood lead and air lead", Atmos. Environ., 19(6):1017-1020.

KEYWORD: Pb, QA, exposure, biomonitoring, demographic, outdoor, literature

Estimates of the slope of the relationship between blood Pb ug/dl (microgram/deciliter) and air Pb ug/m3 obtained in 10 independent studies are compared. No significant differences were detected among the estimates, which ranged from 0.6 to 3.1 ug/dl per ug/m3 and represented male adult, female adult, and child populations. A single best estimate of 1.2 ug/dl per ug/m3 (+/- 0.295 % confidence limits) was obtained. The authors conclude that, if the blood lead-air slope depends on various physical and biological factors, then studies providing more precise estimates are required to detect these differences.

0267
Soczek, M.L., et al. (1986). "The Boston residential NO2 characterization study: an evaluation of survey methodology", Paper no. 86-5.9A, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: NO2, home, ventilation, methodology, source, combustion, monitoring, sampling, design, appliance, field

A large field study of NO2 concentrations and air exchange rates in over 500 households in the Boston, MA, area was conducted by the Harvard School of Public Health Indoor Air Quality Group. This paper evaluates the survey methodology employed in characterizing the homes. Three full periods of indoor monitoring showed that NO2 concentrations in gas households were higher and showed more variance than those in electric households. Indoor concentrations in gas households were higher than outdoor concentrations, and outdoor concentrations were higher than concentrations in electric households. Several important conclusions can be drawn on the design evaluation. While typical response rates for general household samples were around 75%, response rates were lower for studies requiring in-house monitoring. Stratification and clustering generally increase the efficiency of probability-based survey designs, and the results of this study strongly support their use in exposure assessment studies.

0208
Soczek, M.L., Ryan, B.P., Spengler, J.D., Fowler, F.J., and Billick, I.H. (in press) "A survey methodology for characterization of residential NO2 concentrations", J. Air Pollut. Control Assoc.

KEYWORD: NO2, field, methodology, sampling, statistical, home, appliance, activity, source

To create empirical models of indoor NO2 exposure, more data are needed about NO2 emissions from unvented gas appliances, indoor NO2 levels, and people's activity patterns. For this study, the sampling methodology, field protocols, analytical methods, and statistical options are explained thoroughly. A 50-house pilot study tested the survey design.

0191
Sodergren, David (1982) "A CO2-controlled ventilation system", Environ. Int., 8:483-486.

KEYWORD: CO2, radon, aerosol,office,ventilation, foreign,Finland, energy

For buildings in which people are the main source of pollution, the number of people is the limiting factor for air ventilation. When such buildings are not used at full capacity, ventilation, and consequently energy consumption, are unnecessarily high. A great deal of energy could be saved if the ventilation system could adjust the air flow to actual requirements. One possible system would allow the amount of CO2 in the exhaust air to control the ventilation rate. To determine whether this principle is practicable and economical, a CO2 indicator was installed in an office building in Helsinki, Finland. The equipment was used during the winter of 1981-82, and the variation of CO2 and the exterior air flow was registered. The results indicate that the system can be used in new and existing buildings.

0005
Sorensen, A., Botter-Jensen, L., Majborn, B. and Nielsen, S.P. (1985) "A pilot study of natural radiation in Danish homes", Sci. Total Environ., 45:351-356.

KEYWORD: radon,outdoor, foreign, home, field, exposure, seasonal, methodology,Denmark

A pilot study was carried out to establish techniques and procedures for the measurement of indoor radiation in Denmark. A passive cup dosimeter was designed containing CR39 track detectors and TLD's to measure radon and external radiation, respectively. A total of 82 dwellings from most regions of the country were monitored in two three-month periods, one in winter and the other in summer. The average dose rate in air from external radiation was 0.09 microGray/hour. In the winter the average radon concentrations were 88 Becquerel (Bq)/m3 and 24 Bq/m3 for single-family houses and flats, respectively; in the summer the corresponding values were 52 Bq/m3 and 19 Bq/m3.

0458
Speizer, F.E., Ferris, B., Jr., Bishop, Y.M.M., and Spengler, J. (1980) "Respiratory disease rates and pulmonary function in children associated with NO2 exposure", Am. Rev. Respir. Dis., 121:3-10.

KEYWORD: NO2,health,personal, exposure, children,outdoor,monitor, statistical, field, epidemiology, lung, appliance

As part of a long-range, prospective study on the health effects of air pollution, the parents of 8,000 children between the ages of 6 and 10 from 6 communities were asked to complete questionnaires. Simple spirometry was performed on the children in school. Children living in homes with gas stoves were compared to those living in homes with electric stoves. Children from households with gas stoves had an average of 3.2% more respiratory illness before 2 years of age. These children also had small but significantly lower levels of lung capacity (average difference, 16 ml and 18 ml, respectively) when corrected for height. These findings could not be explained by differences in social class or parental smoking habits. Measurements for 24 hours showed that NO2 levels were four to seven times higher in homes with gas stoves than in homes with electric stoves. However, these 24-hour measurements were generally well below the current Federal 24-hour outdoor standard of 100 ug/m3. Short-term peak exposures (exceeding 1,100 ug/m3) regularly occurred in kitchens with gas stoves. Further work will be required to determine the importance of these peaks in explaining the health effects noted.

0651
Spengler, J., Hollowell, C., Moschandreas, D., and Fanger, O., Eds. (1982) "Proceedings of the international symposium on indoor air pollution, health and energy conservation, Amherst, MA, October 13-16, 1981", Environ. Int., 8(1-6):1-534.

KEYWORD: source,exposure,methodology,multipollutant,home, office, ventilation, health, architecture, control, energy, model, TEAM

These 67 papers, selected by peer review from over 95, contribute to understanding sources, concentrations, human exposures, health, and comfort impacts encountered in the indoor environments. Articles on policy and public health concerns pose questions about exposures, population at risk, significance of risk, opportunities, and constraints on intervention that must be studied so that the public's health and welfare are justly served by public and private decisions. The engineering aspects of ventilation, contaminant control, and energy conservation are presented in papers on modeling physical and chemical behavior of pollutants within structures. An author index is included. Appropriate papers from this publication have been abstracted and entered separately into BLIS.

0081
Spengler, J.D., Billick, I., and Ryan, Barry, P. (Aug. 1984) "Modeling population exposures to airborne lead", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 4, chemical

characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 87-94. NTIS PB85-104214.

KEYWORD: Pb, model, population, exposure, vehicle, biomonitoring, interior

This modeling exercise suggests the importance of in-vehicle exposures to air pollutants. The results of the Second National Health and Nutrition Evaluation Survey (NHANES II) on Pb blood level trends vs. ambient air Pb concentrations and leaded gasoline sales suggest the importance of actual personal exposures. Modeled exposures for men in the Turin, Italy, Lead Isotope Experiment provide a better fit to the data than results relying only on ambient concentrations. The few measurements to date indicate that the in-vehicle exposures may be several times greater than the fixed-location ambient concentrations. Direct measurements of personal Pb and in-vehicle Pb concentrations are needed.

0729
Spengler, J.D., Dockery, Douglas W., Reed, M.P., Tosteson, T., and Quinlan, P. (1980) "Personal exposures to respirable particles", Paper no. 80-61.5B, presented at the 73rd annual meeting of the Air Pollution Control Associatioon, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: microenvironment, statistical, source, personal,outdoor, activity,ventilation,exposure,particulate,smoking,vehicle

In spring 1979, 42 nonsmoking adults and four children in Topeka KS, volunteered for a study of personal exposure to particulates. They were already participating in a study of health effects of air pollution. Participants carried personal exposure monitors 3 days per week (15 sampling days at most) in their homes and kept activity diaries. Data for the period were obtained from fixed site monitoring stations. Personal exposures were higher than indoor and outdoor exposures. Variation between individuals and sampling days was significant. Exposure to smokers and automobile exhaust increased exposures. Ambient concentrations may strongly influence indoor and personal exposures. The influence of house variables, transit time, occupation, and other activities remains to be quantified.

0702
Spengler, J.D., Dockery, D.W., Turner, W.A., Wolfson, J.M., and Ferris, B.G., Jr. (1981) "Long-term measurements of respirable sulfates and particles inside and outside homes", Atmos. Environ., 15:23-30.

KEYWORD: outdoor, monitoring, particulate, SO4, field, source, epidemiology, smoking, SO2, home, statistical

The results of extensive indoor and outdoor monitoring for respirable size particles and the sulfate fraction of these particles are reported. The measurements were obtained in conjunction with an epidemiologic study in six cities: Portage, WI; Topeka, KS; Kingston/Harriman, TN; Watertown, MA; St. Louis, MO; and Steubenville, OH. The major source of indoor particulate matter is cigarette smoke, which contributes approximately 20 ug/m-3 to the indoor concentrations for each smoker. Even in homes without smokers, indoor particle concentrations equal or exceed outdoor levels. Indoor respirable sulfate concentrations are consistently lower than outdoors.

0033
Spengler, J.D., Letz, R., Ozkaynak, H., and Soczek, M.L. (1983) "Feasibility of predicting personal or population exposures utilizing ambient air quality models and human activity data", final report for Project 1D639ONASA, U.S. EPA, Strategies and Standards Division, Research Triangle Park, NC 27711 (93 pages). Not available from NTIS.

KEYWORD: SO2, NO2, outdoor, particulate, activity, model, source, EPA$

Time activity patterns are summarized for 332 persons in rural communities of Roane County in eastern Tennessee. This area was chosen because of the presence of coal-fired power plants and the historical data base for SO2 and total suspended particulates, as well as indoor-outdoor monitoring for SO2, NO2, and respirable particulates. The document also describes aerometric data bases and discusses the feasibility of applying atmospheric dispersion models.

0063
Spengler, John D., and Soczek, Mary L. (1984) "Evidence for improved ambient air quality and the need for personal exposure research", Environ. Sci. Technol., 18(9):269-280.

KEYWORD: particulate, Pb, SO2, CO, NO2, aerosol, SO4, literature, NAAQS, personal, exposure, methodology, monitoring

By conventional measures, the quality of the ambient air has steadily improved over the past decade. Although violations of the National Ambient Air Quality Standard for total suspended particulates, SO2, CO, and Pb have decreased, actual personal exposures to air contaminants may not have decreased. This is possible because concentrations of other pollutants, especially

NO2, fine aerosols, and sulfates, may well be increasing. In addition, people typically spend 60% to 90% of their time indoors and may be exposed to elevated levels of pollutants from indoor sources. Several recent personal exposure studies indicate that concentrations of air pollutants measured at central monitoring sites often do not adequately reflect or predict actual personal exposures. Basic approaches used to assess population exposures are compared. Continued research on the relationships between ambient concentrations and actual exposures is needed.

0644
Spengler, John D., and Sexton, Ken (1983) "Indoor air pollution: a public health perspective", Science, 221: 4605, 9-17.

KEYWORD: activity, outdoor, distribution, health, multipollutant, personal, exposure, research, literature

Official efforts to control air pollution traditionally have focused on outdoor air, but elevated contaminant concentrations are common inside buildings. Concerns about health problems due to indoor air pollution are based on evidence that urban residents typically spend more than 90% of their time indoors, concentrations of some contaminants are higher indoors than outdoors, and personal exposures to some pollutants are not adequately characterized by outdoor measurements. Among the most important indoor contaminants associated with health or irritation effects are passive tobacco smoke, radon decay products, CO, NO2, CH2O, asbestos fibers, microorganisms, and aeroallergens. Efforts to assess health risk associated with indoor air pollution are limited by insufficient information about the number of people exposed, the pattern and severity of exposures, and health effects of exposures. An overall strategy should be developed to investigate indoor exposures, health effects, control options, and public policy alternatives.

0265
Spengler, J.D., Duffy, C.P., Letz, R., Tibbits, T.W.,, and Ferris, B.J.,Jr. (Mar. 1983) "Nitrogen dioxide inside and outside 137 homes and implications for ambient air quality standards and health effects research", Environ. Sci. Technol., 17(3):164-168.

KEYWORD: NO2, outdoor, field, microenvironment, source, exposure, monitoring, model

Integrated NO2 measurements were taken by diffusion tube samplers inside and outside 137 homes in Portage, WI. Over a 1-year period, the annual mean ambient NO2 concentrations were 10 to 15 mg/m3. NO2 levels inside the kitchens of 112 homes with gas stoves averaged 50 mg/m3 higher, and bedroom levels were about 30 mg/m3 higher than outdoor levels. Of gas-cooking homes, 10% had annual average kitchen NO2 levels higher than the National Ambient Air Quality Standard of 100 mg/m3. NO2 levels inside the kitchens of 25 homes with electric stoves were two-thirds those of outdoor levels. The variation of NO2 levels among homes due to differences in stove use, emission rates, and air exchange rates impedes the development of prediction models.

0131
Spengler, J.D., Ferris, B.G., Dockery, D.W., and Speizer, F.E. (1979) "Sulfur dioxide and nitrogen dioxide levels inside and outside homes and implications on health effects research", Environ. Sci. Technol., 13(10):1276-1280.

KEYWORD: SO2, NO2, field, outdoor, monitoring, source, appliance

This paper presents the results of 1 year's indoor and outdoor monitoring for SO2 and NO2 in six communities with widely varying outdoor levels. The representativeness of the monitoring in defining exposure is discussed for each city. In four of the communities, outdoor SO2 levels were less than 50% of the annual National Ambient Air Quality Standard, while violations were found in the other two. Annual average indoor levels of SO2 were 20% to 70% of the outdoor levels and never exceeded the standard. Indoor NO2 levels exceeded outdoor levels by a factor of two, depending on the type of cooking appliance used, but did not exceed the standard. The impact of various heating and cooking systems and appliances on the indoor concentrations of these gases is evaluated.

0422
Spengler, J.D., Letz, R., Ferris, B.C. Jr., Tibbits, T.W., and Duffy, C.P. (1981) "Weekly measurements of indoor and outdoor nitrogen dioxide concentrations", presented at the 74th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (14 pages).

KEYWORD: NO2, QA, outdoor, source, field, sampling, appliance, home, exposure

Indoor NO2 concentrations often exceed ambient concentrations when gas-burning appliances are used. Cooking with gas is identified as the principal source for high indoor concentrations of NO2 although gas hot water heaters, dryers, and heaters may contribute to elevated indoor levels. Some recent epidemiologic studies indicate the possibility of health effects presumably associated with NO2 exposure. In conjunction with the on-going Harvard Six City air pollution health study, week-long NO2 concentrations were monitored inside and outside 137 homes in Portage, WI. The gas and electric cooking homes were repeatedly monitored throughout the years 1980-81 using passive diffusion samplers developed by Palmes et al. (1976). The objectives of this program were to characterize spatial and temporal variation between and within homes, and to improve predictions of NO2 exposure for the children participating in the health survey.

0449
Spengler, J.D., Stone, K.R., and Lilley, Frank W. (1978) "High carbon monoxide levels measured in enclosed skating rinks", J. Air Pollut. Control Assoc., 28(8):776-779.

KEYWORD: CO, SO2, NO2, particulate, ventilation, source, health, biomonitoring, regulation, control

CO levels were measured in enclosed skating rinks in Boston, MA. The 1-hour National Ambient Air Quality Standard (NAAQS) of 35 ppm was exceeded in 82% of the sampled hours. In a separate study, alveolar breath samples of 12 Harvard hockey players showed a five-fold increase in carboxyhemoglobin levels after 93 minutes of exercise in air with a relatively low CO concentration of 25 ppm. This paper demonstrates that (1) exercising athletes incur physiologically dangerous levels of carboxyhemoglobin when performing in legal ambient air concentrations of CO (25 ppm) and (2) concentrations of poisonous gas in many indoor skating rinks regularly exceed the NAAQS by as much as 300%. The authors suggest that the Clean Air Act be amended to include indoor public exposure to at least the criteria pollutants of CO, SO2, NO2, and suspended particulates. EPA should require revisions to State Implementation Plans to take into account air pollution exposures indoors. Finally, the authors suggest redesigning rink maintenance machinery to use electric rather than gasoline motors, upgrading pollution control equipment, or routinely using ventilation equipment.

0273
Spengler, J.D., Treitman, R.D., Tosteson, T.D., Mage, D.T., and Soczek, M.L. (Aug. 1985) "Personal exposure to respirable particulates and implications for air pollution epidemiology", Environ. Sci. Technol., 19:(8)700-707.

KEYWORD: particulate, home, personal, exposure, monitor, smoking, outdoor, model, EPA$

Measurements of personal exposures to respirable particles (RSP) were obtained from nonsmoking adults living in two rural Tennessee communities. Personal exposure measurements were compared to simultaneously collected indoor (home) and outdoor concentrations. Personal exposures were higher than, had a greater variance than, and were uncorrelated with outdoor concentrations. Household smoking was a substantial contributor to personal RSP exposure. Ambient concentrations are poor predictors of personal exposures to undifferentiated respirable size particles. Epidemiological investigations of air pollution must consider indoor environments in estimating exposures. Further, the chemical and elemental compositions of indoor concentrations and personal exposures are likely to be different from ambient concentrations. This study indicates the potential for misclassification and misassociation of exposures that are likely to result in relying upon ambient, community-based particle measurements.

0591
Spengler, John D., and Cohen, Martin A. (1985) "Emissions from indoor combustion sources", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 261-278.

KEYWORD: combustion, source, emission, multipollutant, exposure, literature

Unvented combustion of biomass fuels or fossil fuels and pyrolysis of vegetation, oils, food, or building materials can generate a variety of gaseous and particulate matter. Cleaner, low-molecular-weight fuels (such as methane and propane) produce CO2, CO, NO, NO2, and H2O upon combustion. Depending on fuel additives, reduced sulfur compounds, nitrates, hydrocarbon fragments (including aldehydes), and hydrogen cyanide may be produced. Reported literature focuses on CO, NO, and NO2 measurements. Combustion of kerosene produces many of the same contaminants as combustion of gaseous fuels. In addition, kerosene burners are a source of ultrafine particles comprised primarily of unburned or condensed hydrocarbons. In developing countries, biomass fuels such as crop residue, wood, charcoal, soft coal, and animal dung are used for cooking and heating. As a result, researchers in rural India have measured particulate concentrations of several milligrams per cubic meter and benzo-a-pyrene concentrations of micrograms per cubic meter.

0610
Spicer, C.W., et al. (1986) "Intercomparison of sampling techniques for toxic organic compounds in indoor air", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711,

pp. 45-60. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: exposure, field, home, methodology, statistical, VOC, halocarbon, aromatic, hydrocarbon, sampling, laboratory,EPA$

Several techniques for sampling volatile organic chemicals (VOCs) were compared indoors, including distributive air volume sampling, high- and low-rate passive sampling, and whole air collection in canisters. The study focused on chloroform, 1,1,1-trichloroethane, benzene, bromodichloromethane, trichloroethylene, toluene, tetrachloroethylene, styrene, p-dichlorobenzene, and hexachlorobutadiene. Ten 12-hour samples were collected--for eight, the indoor air was spiked with the target compounds in nominal concentrations of 3, 9, and 27 ng/L. The other two samples were the background air of the residence Correlation coefficients were generally high (greater than 0.90) between the methods. Benzene had lower correlation coefficients. In general, distributive air volume sampling and low-rate passive sampling measure concentrations less than or equal to the canister method.

0036
Squirrel, M. (1985) "Indoor air quality", Environ. Health, 93(11):299-301.

KEYWORD: source, literature

This article discusses the sources of indoor air pollutants, including moisture, combustion gases, suspended particulates, SOx, NOx, hydrocarbons, CO, photochemicals, metals, microbes, radioactive substances, formaldehyde, asbestos, fungicides, timber preservatives, tobacco smoke, human metabolic products, and CO2.

0329
Stark, A.D., Quah, R.F., Meigs, J.W., and DeLouise, E.R. (1982) "The relationship of environmental lead to blood-lead levels in children", Environ. Res., 27:372-383.

KEYWORD: biomonitoring,home,model, statistical, children, water, source, Pb

The distribution of Pb residential sources of 377 children in New Haven, CT, was studied. Substantial amounts of Pb were present in soil, paint, and house dust throughout New Haven, but not in air or water. Multiple regression modeling indicated that the most important contributors to variation in children's blood Pb levels were soil and Pb-containing exterior house paint. Using the best five-variable model, only 11.7% of the variation in the children's blood Pb levels could be explained. Researchers concluded that residential Pb sources did not account for most of the observed variation.

0123
Starr, H.G., Aldrich, F.D., McDougal, W.D., and Mounce, L.M. (Dec. 1974) "Contribution of household dust to human exposure to pesticides", Pestic. Monit. J., 8(3):209-213.

KEYWORD: particulate, pesticide, health, home, DDT, exposure, dieldrin, lindane, chlordane, biomonitoring

Preliminary analyses reveal household dust as a major reservoir of pesticides in the environment. Households with pesticides and control households monitored in Weld County, CO, in 1968 demonstrate appreciable levels of selected chlorinated pesticides in those living in pesticide households. No quantitative relationships were demonstrated between pesticide levels in household dust and in blood, although circumstantial data from individual households indicate a relationship.

0584
Steinhausler, Fritz (1985) "European radon surveys and risk assessment", Gammage R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 109-129.

KEYWORD: radon, literature, foreign, dose, source, control, home, exposure,temperature,methodology,risk,epidemiology,Europe

In western Europe, several large-scale national programs have been initiated in the past few years to assess the exposure of the general population to radon and its daughters. The overall effort is carried out by the Commission of the European Communities (CEC), under the 1980-84 Radiation Protection Research Programme. To ensure the comparability of the data obtained in several national studies, CEC has organized an international intercomparison program in close collaboration with the Organization for Economic Cooperation and Development-Nuclear Energy Agency in Paris, France. The program will address the largely varying key issues ranging from exhalation studies to lung cancer risk assessments in the various European national programs, as well as the current view of the regulatory aspects of the control of indoor radon daughter exposure.

0376
Sterling, D.A., Stock, T.H., and Monteith, D.K. (1984) "Factors influencing formaldehyde levels in manufactured housing", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 139-144. NTIS PB85-104206.

KEYWORD: CH2O, source, home, temperature, ventilation, appliance, exposure

A pair of identical mobile homes, one with electric heating and cooking utilities and the other with propane gas utilities, were used to evaluate various factors that may affect indoor formaldehyde concentrations. Over 14 months, formaldehyde levels in both homes decreased approximately 33% under similar environmental conditions. However, short-term effects due to daily variations of indoor temperature and air-exchange rate may be more important factors. Formaldehyde levels fluctuated 20 to 40% over a 24-hour period even with a relatively constant indoor temperature of 21 (+/- 2) degrees C. An increase of 8 degrees C doubled the measured formaldehyde concentration, while opening windows (approximately increasing the air-exchange rate 25-fold) decreased formaldehyde up to 50% within 20 minutes. Using propane as a cooking source did not increase formaldehyde concentrations.

0595
Sterling, David A. (1985) "Volatile organic compounds in indoor air: an overview of sources, concentrations, and health effects", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 387-402.

KEYWORD: health, exposure, literature, exposure, VOC,ventilation, multipollutant, source, outdoor, energy

Contaminant levels indoors are often higher than outdoors, sometimes exceeding ambient and even occupational standards. Energy conservation measures that serve to "tighten" building structures have intensified indoor air quality problems. In these structures, indoor air contaminants may be a significant health hazard. Volatile organic compounds (VOCs) have been measured from numerous indoor sources such as construction materials, furnishings, consumer products, pesticides, combustion fuels, and occupants. Many more organic vapors are found indoors than outdoors and typically in greater concentrations. More than 250 organic compounds (over 1 ppb) have been identified in indoor air, and nearly every class of compounds is represented. Health effects observed from exposure to organic vapors come primarily from occupational studies where a compound may typically be singled out, and concentrations and exposures can be estimated. VOCs found indoors are in greater numbers and lower concentrations than in occupational settings. Additive or synergistic effects may be important for long-term, low-level exposures. Although many of the common compounds measured in indoor air are relatively inert, known and suspected mutagens and carcinogens have also been measured.

0194
Sterling, David, Clark, C., and Bjornson, S. (1982) "The effect of air control systems on the indoor distributions of viable particles", Environ. Int., 8:409-414.

KEYWORD: microorganism, particulate, field, ventilation, control, method

The filtering effects of three types of air control systems of enclosed structures on viable particles in the ambient air were investigated. Aspergillus fumigatus and other thermophilic organisms were used as monitors for viable particles. The indoor concentrations of viable particles were affected by building design and the use of conventional mechanical air systems. Viable particles of approximately 4.0 um and greater in aerodynamic diameter were filtered from the air, while respirable size particles less than 4.0 um were not filtered. There was evidence of growth of viable particles within the mechanical air systems. Conventional air control systems may not adequately control viable particles indoors without modifications and proper maintenance.

0342
Sterling, E.M., and Sterling, D.A. (1984) "Air quality in hospitals and health care facilities", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 209-214. NTIS PB85-104222.

KEYWORD: ventilation, energy, control,exposure,sampling,hospital

In addition to air quality problems encountered in other sealed buildings, both workers and patients in hospitals may be exposed to very special air contaminant problems. Levels and ranges of a variety of chemical pollutants measured in 16 hospitals are reviewed using a computer-based Building Performance Information System (BPIS). A number of anesthetic gases and sterilization agents (halothane, N2O, and ethylene oxide) appear at relatively high levels that present hazardous conditions for hospital workers and patients. Energy conservation in buildings (including hospitals) has concentrated on reducing ventilation. Hospitals, because of special potentially hazardous conditions, may be even more prone to problems than office or other public buildings. Any energy conservaton strategy must seek to guarantee reasonable air quality in hospitals.

0284
Sterling, E.M., and Sterling, T.D. (1985) "Interrelations among different ventilation parameters and indoor pollutants", ASHRAE Trans., Vol. 91, Part 2, Paper No. 2925, (8 pages).

KEYWORD: CO, CO2, particulate, field, hydrocarbon, ventilation, exposure

A number of ventilation parameters and pollutants were measured at 21 locations, furnishing data for evaluating interrelations among commonly used descriptors of ventilation as well as their relation to frequently measured indoor pollutants (including CO2, CO, particulates, and hydrocarbons). The analysis of the data is presented in three sections: (1) the comparison of different ventilation measures, (2) the relationship between ventilation and pollutant concentrations across buildings, and (3) the relationship of pollutants to ventilation measures in specific buildings. The data show that (1) ventilation parameters based on estimated building use do not necessarily describe ventilation factors based on actual building use, so that ventilation requirements related to occupancy considerations alone may not adequately control indoor air quality, (2) CO2 concentrations respond quite differently to changes in ventilation than hydrocarbons, CO, and particulates, which appear to depend mainly on outside levels, and (3) pollutant concentrations appear to approach asymptotic values with increasing ventilation. These asymptotes seem to be determined by the building and its outdoor environment and may be only marginally affected by increased ventilation.

0450
Sterling, T.D., and Sterling, E. (1979) "Carbon monoxide levels in kitchens and homes with gas cookers", J. Air Pollut. Control Assoc., 29(3):238-241.

KEYWORD: home, ventilation, exposure, activity, source, CO, combustion, appliance

It generally has been assumed that (1) only a small amount of CO will be produced by a gas stove when the air-gas mixture is well adjusted and (2) the small amount of CO produced will be dissipated by the home's ventilation and a combination of a fan and hood over the stove. However, meal preparation may substantially increase CO levels. The immediate air supply may be progressively diminished when more than one burner is used, and the air supply may be partially cut off by vessels placed over the flame. This investigation attempted to determine the amount of CO that may be expected to be produced during normal cooking. The experiment measured CO levels, using multiple burners with and without cooking vessels, and the rate of dissipation of the accumulated gas under various conditions of ventilation.

0633
Sterling, Theodor, and Kobayashi, Diana M. (1977) "Exposure to pollutants in enclosed living spaces", Environ. Res., 13:1-35.

KEYWORD: outdoor,exposure,microenvironment,literature,combustion, multipollutant, source

Enclosures such as homes and vehicles protect people from toxic substances, but they may entrap pollutants that have seeped in from the outside or have been generated inside. Studies on enclosed environments are grouped here into into four categories, each of which is discussed separately: homes, artificially sealed environments such as submarines, public buildings, and transportation - related enclosures. Pollution levels reported from different studies are summarized in a series of appended tables. The concentrations of toxic vapors and dusts indoors may very well exceed concentrations outdoors.

0692
Stock, Thomas H., and Mendez, Sixto R. (1985) "A survey of typical exposures to formaldehyde in Houston area residences", Am. Ind. Hyg. Assoc. J., 46(6):313-317.

KEYWORD: home, CH2O, field, ventilation, control, distribution, exposure

Indoor air quality during warm weather was surveyed in a variety of Houston, TX, area residences not selected in response to occupant complaints. Indoor formaldehyde concentrations ranged from less than 0.008 ppm to 0.29 ppm, with an arithmetic mean of 0.07 ppm. Approximately 15% of the monitored residences exceeded 0.01 ppm. Formaldehyde levels depended on both age and structural classification of the residence. These factors are dependent of each other and more fundamental variables, such as the rate of exchange of indoor and outdoor air and the overall emission potential of indoor materials. This survey suggests that people may be exposed to excess (> 0.10 ppm) formaldehyde in many homes, indicating the need to improve control strategies.

0281
Stock, Thomas H., et al. (Dec. 1985) "The estimation of personal exposures to air pollutants for a community-based study of health effects in asthmatics--design and results of air monitoring", J. Air Pollut. Control Assoc., 35:(12)1266-1273.

KEYWORD: multipollutant, EPA$, field, exposure, outdoor, weather, monitoring

To provide reliable pollutant and meteorological exposure estimates for an epidemiological study of asthmatics residing in two Houston, TX, neighborhoods, a dedicated three-tier air monitoring system was established. This consisted of fixed-site ambient air monitoring at the center of each study area, a mobile van performing simultaneous indoor and outdoor measurements at selected residences of study participants, and a limited amount of direct personal monitoring for half of the participants. Monitored pollutants included all criteria pollutant gases, as well as aeroallergens, aldehydes, total suspended particulates, and inhaled particulates. Laboratory analyses provided concentrations of sulfate, nitrate, and trace elements. Several meteorological parameters also were continuously measured. O3 was the only measured pollutant that exceeded the National Ambient Air Quality Standard during the May-to-October study period. The monitoring scheme allowed important pollutant concentration differences to be detected between day and night, between indoors and outdoors, and among various indoor environments.

0587
Stolwijk, J.A.J., Leaderer, B.P., and Berwick, M. (1985) "Experimental considerations in the measurement of exposures to sidestream cigarette smoke", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 205-213.

KEYWORD: smoking, exposure, methodology, epidemiology, health

Evidence is increasing that chronic passive cigarette smoking can cause respiratory irritation, infection, and cancer. However, measuring exposure to smoke and possible health effects is complicated by the chemical complexity of tobacco smoke, ignorance of how easily these chemicals contact and enter respiratory tissues, and the extreme range of smoke concentrations. As a result, no universally accepted methods exist for measuring tobacco smoke exposures or health effects. The major types of methods, often used in combinations, are (1) microenvironmental or personal measurements of one or more smoke constituents, (2) measurement of concentrations of these constituents or their metabolic by-products in blood, breath, urine, or tissues, (3) surveys of smoker and victim densities, ventilation, and/or activity patterns, and (4) analysis of health and demographic data.

0266
Stone, Robert, et al. (March 1981) "Evaluation of formaldehyde in residential mobile homes", U.S. Department of Transportation, Washington, DC (195 pages). NTIS PB82-144619.

KEYWORD: model, CH2O, home, regulation, health, economic, control

The extent of formaldehyde contamination inside residential mobile homes was investigated. A computer model was developed to aid the U.S. Department of Housing and Urban Development in evaluating potential alternatives for regulating maximum formaldehyde levels for new mobile homes. Health costs associated with formaldehyde exposure were examined to establish baseline costs to mobile home occupants in the absence of regulation.

0382
Sugawara, F., and Yoshizawa, S. (1984) "Size distribution of airborne fungal and bacterial particles in Japanese buildings", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 241-246. NTIS PB85-104206.

KEYWORD: microorganism, particulate, source, foreign, sampling, Japan

This study presents the results of an attempt to determine the size distribution of indoor airborne fungal and bacterial particles using an Andersen air sampler (six stage). The study was carried out in 1978-82 in the Tokyo, Japan, area. The size distribution of fungal particles was similar to log-normal distribution with peaks around 3.5 um in diameter irrespective of seasons, spaces, or concentration levels. Distribution of cladosporium particles alone was almost the same. Bacterial particles did not show definite distribution types. The differences in size distributions seem to come from the mechanism of liberation into air. The median diameter was about 3.5 um for fungi and 5.5 to 6.5 um for bacteria.

0352
Syversen, T.L.M., Eide, I., and Malvik, B. (1984) "Chemical air quality in energy-efficient houses", Berglund, B., Lindvall, T.,

and Sundell, J., Eds.,"Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 529-533. NTIS PB85-104222.

KEYWORD: CH2O, particulate, home,field,alkane,VOC, radon, energy, ventilation, source

Chemical pollutants and ventilation rates were measured in energy-efficient private dwellings. The samples were taken with no human activity in the houses. The main source of organic pollutants seems to be indoor building materials and furniture. For dust, an important source could be the outdoor environment. Formaldehyde was primarily found in houses with chipboard. Radon daughters were very low in all houses tested.

0585
Tager, Ira B. (1985) "Passive cigarette smoke: overview", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds.,"Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 191-194.

KEYWORD: smoking, exposure, health, methodology, monitoring, economic, activity, aerosol

The potential health consequence of exposure to passive cigarette smoke has become a subject of increased scientific and public debate. However, many issues remain to be resolved before a clearer picture of these consequences can emerge. Identification and quantitation of environmental tobacco smoke presents problems related to the selection of the most relevant chemical compounds in terms of health effects. (Some cigarette compounds are previewed by other sources.) Nicotine is a unique component, but its relationship to other constituents of tobacco smoke is poorly understood. The many factors that influence accumulation of products of tobacco smoke have not been properly controlled in most studies. The interplay of factors that influence deposition of an aerosol such as passive smoke requires elaboration so that actual exposures can be more accurately estimated. Current studies of the potential health effects of passive exposure to cigarette smoke have suggested effects on acute and chronic cardiopulmonary morbidity. However, methods for detecting exposure are complicated by the incomplete control of potential confounding factors (family size, socioeconomic status, etc.). Thus, further investigation is needed.

0371
Tartaglia, M.S., DiNardi, S.R., and Ludwig, J.F. (1984) "A comparison of calibration procedures for an automatic formaldehyde analyzer", Berglund, B., Lindvall, T., and Sundell,

J., Eds.,"Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 75-80. NTIS PB85-104206.

KEYWORD: CH2O, QA, methodology, home, exposure

Obtaining reliable continuous data on residential formaldehyde levels with the CEA Model TGM 555 Air Monitor requires an accurate and precise method of calibration. Calibrations were compared with liquid standards prepared from refluxed paraformaldehyde in water, liquid standards prepared from 37% solution of formaldehyde in water, and dynamic gaseous formaldehyde standards generated with a permeation tube. The CEA was modified to avoid the use of the toxic mercuric chloride reagent. The modified CEA was calibrated with the paraformaldehyde liquid standard and the gaseous standard. The three calibration methods, the modified instrument, and the results of the comparisons are discussed.

0769
TerKonda, Purush K., and Liaw, Shu-Liang (1983) "Monitoring of indoor aldehydes", Frederick, Edward R., et al., Eds., "Proceedings of the specialty conference on measurement and monitoring of noncriteria (toxic) contaminants in air, held in March of 1983 ", Publication no. SP-50, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230, pp. 435-440.

KEYWORD: aldehyde ,CH2O,regulation,source, monitor, home, office, sampling, ventilation, methodology

Both total aliphatic aldehydes (RCHO) and formaldehyde (CH2O) have produced numerous serious consumer complaints, forcing some state agencies and the Consumer Product Safety Commission to impose a ban and regulations on CH2O, particularly urea formaldehyde foam insulation (UFFI). In this research, various nonoccupational indoor environments (including mobile homes, apartments, single family homes with and without UFFI, offices, and public buildings) were monitored for RCHO and CH2O for 1 year. Indoor samples were taken with 3-impinger trains in each environment simultaneously using 0.05% MBTH (3-methyl-2-benzothiazoline hydrazone hydrochloride) solution to absorb RCHO and deionized distilled water for CH2O. Samples were analyzed immediately with the MBTH procedure for RCHO and pararosaniline procedure for CH2O with a spectrophotometer. RCHO concentrations ranged between 10 and 600 ug/m3 and CH2O concentrations between 10 and 480 ug/m3. Factors affecting these indoor concentrations included sources of aldehydes, ventilation rate, and age of building.

0279
Thomas, J., Mage, D., Wallace, L., and Ott, W. (May 1985) "A sensitivity analysis of the enhanced simulation of the human air pollution exposure (SHAPE) model", EPA contract 68-01-6595, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (126 pages). NTIS PB85-201101/REB.

KEYWORD: CO, SHAPE, distribution, microenvironment, model, EPA$, exposure, biomonitoring

A sensitivity analysis was undertaken of the Simulation of Human Air Pollution Exposure (SHAPE) model. The SHAPE model simulates the physical activities of a sample of people in an urban area, exposing them to pollutant concentrations from appropriate microenvironments as they move through time and space in a 24-hour period. To conduct this sensitivity analysis, the SHAPE program was run many times using a different combination of values for its parameters, thus allowing the contribution to blood carboxyhemoglobin of each of many variables to be examined. The following phenomena had considerable effect on the predicted frequency distribution of the maximum COHb levels of the population: (1) CO exposure time pattern (CO exposure as a function of time), (2) CO exposure contributed by the highway microenvironment, (3) altitude of the city, and (4) the physiological parameters (e.g., Haldane parameter and endogenous CO production rate).

0670
Thompson, C. Ray, Hensel, Earl G., and Kats, Gerrit (1973) "Outdoor-indoor levels of six air pollutants", J. Air Pollut. Control Assoc., 23(10):881-886.

KEYWORD: PAN,NO2, CO, particulate, NO, seasonal, control,outdoor, ventilation, office, O3, school, home, monitor, weather

Levels of six air pollutants--total oxidant, peroxyacetyl nitrate (PAN), NO, NO2, CO, and particulate matter--were compared outside and inside 11 buildings in the South Coast Basin of California during summer and fall. Total oxidant levels inside depend upon how much outside air is being brought in and the residence time in the structure. With rapid intake and circulation, levels inside may be two-thirds those outside. With slow intake and circulation, levels inside decay to near zero. PAN is more persistent in buildings because it is more stable than ozone but also decays to low levels over an extended period. NO, NO2 and CO are much more stable than oxidants or PAN, and when carried into buildings remain until diluted or exhausted. Particulate matter levels indoors depend largely upon velocity of air movement. In areas where foot traffic was light or ventilation rates low, levels were reduced. Electrostatic precipitators were much more effective than the coarse primary filters used in many buildings for removing particulate matter.

0613
Tichenor, B. A., Jackson, M. D., and Merrill, R. G. (1986) "Measurement of organic emissions from indoor materials -- small chamber studies", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 86-94. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: emission, laboratory, source,VOC, methodology, humidity, temperature, ventilation, control, EPA$

Volatile organic compounds indoors have been measured at concentrations exceeding those found outdoors. EPA's Air and Energy Engineering Research Laboratory is conducting studies in small environmental chambers to develop emissions data for indoor sources of these compounds. The studies include gas chromatograph measurements of a variety of organic compounds emitted from selected indoor materials (e.g., particle board, flooring adhesive, caulking compounds). Environmental conditions (i.e., temperature, humidity, air-exchange rates) vary, and their influences on emission rates can be determined. Data are presented for emissions from a clear acrylic latex caulk with silicone. These data show the variation in concentrations and emission factors over time for total measured organics and selected organic species.

0534
Tokiwa, Y., Tamplin, B.R., and Nadel, J.A. (1965) "Monitoring human exposures to sulfur dioxide in a body plethysmograph", J. Air Pollut. Control. Assoc., 15(3):96-98.

KEYWORD: exposure, lung, health, methodology, laboratory, SO2

A procedure is described for producing a SO2-contaminated atmosphere within a body plethysmograph, exposing subjects to this atmosphere while maintaining the SO2 concentration at a given level, and measuring the concentration with less than 1 minute of lag time. Incremental volumes of SO2 were introduced via syringe, thus limiting the maximum SO2 concentration in the chamber and ensuring the subject's safety. A Titrilog SO2 analyzer with its rapid response characteristics provides quick measurements of the SO2 concentration. The body plethysmograph used in this manner serves simultaneously as a device to measure pulmonary function and as an exposure chamber.

0200
Tosteson, T.D., Spengler, J.D., and Weker, R.A. (1982) "Aluminum, iron, and lead content of respirable particulate samples from a personal monitoring study", Environ. Int., 8:265-268.

KEYWORD: particulate, Fe, Al, Pb, outdoor, personal, exposure, field, literature, vehicle, interior

Samples of respirable particulate matter collected during a personal monitoring study in Topeka, KS, were analyzed for iron, aluminum, and Pb. The sampling protocol and instrumentation are described in detail. Pb indoor concentrations (median = 79 ng/m3) were less than both personal (median = 112 ng/m3) and outdoor Pb concentrations (median = 106 ng/m3). The indoor, outdoor, and personal levels of Fe and Al were not significantly different. In addition, outdoor respirable particulate mass does not correlate well with the personal or indoor metal concentrations, and the amount of time spent in motor vehicles is a relatively good indicator of Pb exposures. The relationships between indoor, outdoor, and personal Pb are discussed in greater detail, with references to supporting evidence from other studies.

0709
Traynor, G.W., Anthon, D.W., and Hollowell, C.D. (1982) "Technique for determining pollutant emissions from a gas-fired range", Atmos. Environ., 16(12):2979-2987.

KEYWORD: CO,NO,SO2,CH2O,particulate,combustion,model,appliance

Laboratory measurements from a gas-fired range have shown that CO, NO, SO2, formaldehyde, and respirable particles were emitted during combustion. Carbon was the dominant element of the respirable particles emitted. A mathematical indoor air quality model was applied to the studies to calculate pollutant emission rates per caloric value of fuel consumed. The model was also used to calculate the temporal profile of the indoor pollution concentrations as well as to determine indoor pollutant decay rates from mechanisms other than air infiltration. Measured and calculated data showed good agreement, suggesting that this model may be useful for determining pollutant emissions from a wide variety of other sources, estimating pollution levels in other indoor microenvironments, and evaluating pollutant control strategies.

0673
Traynor, G.W., Apte, M.G., Sokol, H.A., Chuang, J.C., and Mumford, J.L. (1986) "Selected organic pollutant emissions from unvented kerosene heaters", Paper no. 86-52.5, presented at the 79th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (20 pages).

KEYWORD: VOC, combustion, source, laboratory, PAH, PCP, kerosene, EPA$ aromatic, phthalate, ketone, alcohol, naphthalene, benzene

An exploratory study assessed emissions of semivolatile and nonvolatile organic compounds from unvented kerosene space heaters; one a well-tuned radiant heater and the other a maltuned convective heater. Each was operated in a 27-m3 chamber with a prescribed on/off pattern. Organic compounds were collected on Teflon-impregnated glass filters backed by XAD-2 resin and analyzed by gas chromatography/mass spectrometry. Pollutant source strengths were calculated using a mass-balance equation. The results showed that kerosene heaters can emit polycyclic aromatic hydrocarbons (PAHs), nitrated PAHs, alkyl benzenes, pentachlorophenol, phthalates, hydronaphthalenes, aliphatic hydrocarbons, alcohols, ketones, and other organic compounds.

0269
Traynor, G.W., Girman, J.R., Apte, M.G., Dilworth, J.F., and White, P.D. (1985) "Indoor air pollution due to emissions from unvented gas-fired space heaters", J. Air Pollut. Control Assoc., 35(3):231-237.

KEYWORD: CO, NO2, NO, CO2, CH2O, particulate, source,laboratory, c ombustion, gas, appliance, emission, home, ventilation

Unvented combustion appliances can elevate indoor pollution concentrations. Under laboratory conditions, O2 consumption rates and rates of CO, CO2, NO, NO2, formaldehyde, and submicron suspended particles emitted from eight unvented gas-fired space heaters operated with well-adjusted air shutters at partial and full fuel consumption rates were determined in a 27-m3 chamber. Emission rates were also determined for some heaters operating under poorly tuned conditions. Four of the eight heaters were subsequently tested in a 240-m3 research house with 0.36 to 1.14 air changes per hour. These steady-state levels were projected: 100 ppm CO2, 1.0 to 26 ppm CO (under well-tuned conditions), 0.40 to 1.46 ppm NO2, and 19.1% to 20.7% O2. Concentrations of CO2, CO, and NO2 sometimes exceeded outdoor or occupational guidelines. Analysis showed that CO, NO, and NO2 emission rates derived from laboratory tests were consistent with initial emission rates observed in the field. However, they did not always correspond to steady-state emission rates.

0710
Traynor, G.W., Nitschke, I.A., Clarke, W.A., Adams, G.P., and Rizzuto, J.E. (1985) "A detailed study of thirty houses from indoor combustion sources", Paper no. 85-30A.3, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (16 pages).

KEYWORD: home,exposure,ventilation,monitoring,source, combustion, activity,model,multipollutant,seasonal,weather,field

In this initial survey, 30 houses with combustion sources in northeastern and central New York State were selected somewhat randomly. Using active and passive integrating samplers, NO2, CO, respirable particulates (RSP), formaldehyde (CH2O), and air exchange rates were monitored for 41 1-week periods. In winter, home owners logged combustion source usage. During follow-up real-time monitoring, the 6 houses with highest combustion pollutant levels were monitored for NO, NO2, RSP, CO, and CO2. Weather and air exchange rate data also were gathered in real-time. Correlations between source usage and real-time pollutant concentrations are described and modeled.

0543
Traynor, Gregory W., et al. (1983) "Indoor air pollution due to emissions from unvented gas-fired space heaters", Paper 83-9.6, presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (35 pages).

KEYWORD: combustion, source, NO, CO, emission, CH2O, NO2, home, particulate, CO2, laboratory, ventilation, appliance

Unvented combustion appliance can elevate indoors pollutant concentrations. Under laboratory conditions, the oxygen consumption rates and the pollutant emission rates were determined for CO, CO2, NO, NO2, formaldehyde, and submicron particles emitted from eight unvented gas-fired space heaters operated with well-adjusted air shutters at partial and full input in a 27-m3 chamber. Emission rates were also determined for some heaters operating under poorly tuned conditions. Four of the eight heaters were subsequently tested in a 240-m3 research house with 0.36 to 1.14 air changes per hour. Based on measurements near steady state, the authors projected these steady-state pollutant and oxygen levels: 1,930 to 11,100 ppm for CO2, 1.0 to 26 ppm for CO (under well-tuned conditions), 0.40 to 1.46 ppm for NO2, and 19.1 to 20.7% for 02. CO2, CO, and NO2 were sometimes observed to be above outdoor concentrations or occupational guidelines. CO, NO, and NO2 emission rates can vary with time and, while short-term emission rates derived from laboratory tests were consistent with initial emission rates observed in the field, these rates did not always correspond to steady-state emission rates.

0351
Traynor, G.W., Apte, M.G., Carruthers, A.R., Dillworth, J.F., Grimsrud, D.T., and Thompson, W.T. (1984) "Indoor air pollution and inter-room pollutant transport due to unvented kerosene-fired space heaters", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 5, buildings, ventilation and thermal climate", Swedish Council for Building Research, Stockholm, pp. 523-528. NTIS PB85-104222.

KEYWORD: CO, CO2, NO, NO2, O2,exposure, temperature, ventilation, home, kerosene, field, combustion, emission

Two kerosene-fired space heaters, one white-flame convective and one blue-flame radiant, were operated in the master bedroom of an unoccupied house under several simulated use conditions. Tests were conducted with the bedroom door and outside window closed, with the door closed and the window open 2.5 cm, with the door open 2.5 cm and the window closed, and with the door wide open and the window closed. The heaters were operated until the temperature rose 8 degrees C in the bedroom. Bedroom concentrations of CO, CO2, NO, NO2, and O2 increased. The increases in CO2 levels ranged from 2,440 to 5,440 ppm, while the increases in NO2 levels ranged from 0.12 to 0.60 ppm. In addition, inter-room pollutant transport rates were determined with the window closed. While the rates were less than 10 m3/hour with the bedroom door closed, they were 30 (+/- 10) m3/hour with the bedroom door open 2.5 cm, and ranged from 190 to 3,400 m3/hour with the door fully open (74 cm).

0765
Traynor, G.W., Apte, M.G., Carruthers, A.R., Dillworth, J.F., Grimsrud, D.T., and Gundel, L.A. (1984) "Indoor air pollution due to emissions from wood burning stoves", Paper no. 84-33.4, Presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (10 pages).

KEYWORD: EPA$,CO,NO,NO2,CH2O,particulate,home,combustion,outdoor, PAH, energy, method, monitor, sample, source, wood

Emissions of CO, NO, NO2, formaldehyde (CH2O), total suspended particles (TSP), submicron particles (<0.6 um), and polynuclear aromatic hydrocarbons (PAH) from four wood-burning stoves were determined in a single-floor test house in Truckee, CA (elevation: 1800 meters). All pollutants were measured in real time, except for CH2O which was measured with a bubbler/collector. Three airtight stoves did not emit significant amounts of pollutants indoors, while one nonairtight stove emitted high amounts of CO and PAH-containing suspended particulates. TSP concentrations were greater indoors than outdoors, including when no stove was in use. Indoor and outdoor NO and NO2 concentrations were very low for all tests. CH2O levels were also low in general. All stoves emitted at least trace amounts of CO.

0512
Traynor, G.W., Apte, M.G., Dillworth, J.F., and Grimsrud, D.T. (1983) "Indoor air pollution from portable kerosene-fired space heaters", U.S. Department of Energy, Office of Energy Research, Office of Health and Environmental Research, Washington, DC 20585 (15 pages). NTIS DE83-009140.

KEYWORD: home, combustion, NO2, ventilation,laboratory, emission, exposure, field, outdoor, kerosene, CO

Unvented combustion appliances used indoors are known to increase indoor air pollutant levels. Laboratory tests were conducted on unvented portable radiant and convective kerosene-fired space heaters to identify the pollutants emitted and to determine the emission rates. CO and NO2 emission rates were determined. The researchers presummarized the effect of wick height and fuel consumption rate on CO and NO2 emissions. Pollutant-concentration profiles resulting from kerosene heaters used in a 27-m3 environmental chamber and a 240-m3 house were also determined. When such heaters are operated for 1 hour in a 27-m3 chamber with 0.4 air changes per hour, the resultant CO2 concentrations are well above the U.S. occupational standard, and NO2 concentrations are well above California's short-term outdoor standard. Further data on parameters such as heater-use patterns and air-exchange rates are needed to determine the actual pollutant exposure that kerosene heater users experience.

0190
Traynor, G.W., Apte, M.G., Dillworth, J.F., Hollowell, C.D., and Sterling, E.M. (1982) "The effects of ventilation on residential air pollution due to emissions from a gas-fired range", Environ. Int., 8(1-6):447-452.

KEYWORD: multipollutant,model,home,source,combustion,ventilation, control, method, gas, appliance

Indoor combustion appliances can increase the levels of many different pollutants. The usefulness of a model for extrapolating environmental chamber results on pollutant emissions from combustion appliances to determine pollutant concentrations in actual residences is shown. In addition, the effects of infiltration, whole-house ventilation, and spot ventilation on pollutant levels are investigated. Pollutants from a gas range were measured at an unoccupied experimental research house. The results show that a range hood is the most effective means of removing pollutants emitted from a gas-fired range; removal rates were from 60% to 87%.

0688
Tu, K.W., and Hinchliffe, L.E. (1983) "A study of particulate emissions from portable space heaters", Am. Ind. Hyg. Assoc. J., 44(11):857-862.

KEYWORD: source, appliance, particulate, ventilation, exposure, combustion

Particulate emissions from five portable space heaters were studied in a 31-m3 room with a ventilation rate of 3 air-changes/hour and in an 11-m3 air-tight chamber. The five were: three conventional electrical space heaters having different heating elements--a heavy coil, a thin strip, and a fine coil--one new-style electrical heater in which the heating element is enclosed in a quartz tube, and a modern type of kerosene burner with a wire-heating mantle housed in a heat chamber. The conventional electrical heaters produced ultrafine particles, while the quartz and kerosene heaters released larger particles of up to 3 um in diameter. The particle number and mass concentrations were in the ranges of 10,000-1,000,000-106 particles/cm3 and 1-300 ug/m3, respectively. The kerosene heater released 1 to 2 orders of magnitude more particles, both in mass and number, than the other heaters. These particles were a mixture of individual solid and hollow spheres with sizes up to 0.3 um, and clusters and chain aggregates in the range of 0.1 to 3 um.

0419
Turiel, I., Hollowell, C., Miksch, R.R., Rudy, J.V., and Young, R.A. (1983) "The effects of reduced ventilation on indoor air quality in an office building", Atmos. Environ., 17(1):51-64.

KEYWORD: CO2, CH2O, VOC, microorganism, particulate, ventilation, CO, NO2, exposure, health, field, office

Indoor air quality was monitored at an office building in San Francisco, CA, where occupants had registered eye, nose, and throat irritation complaints. Portable air pollution monitoring equipment was placed on site to monitor air outdoors and at three indoor sites (a waiting room, an interview room, and an office room), and data were taken under two different ventilation rates. The parameters measured were outside air flow rates, temperature, relative humidity, odor perception, microbial burden, particulate mass, formaldehyde and other organics, CO_2, CO, and NO_2. CO_2 concentrations increased as the ventilation rate decreased; odor perceptibility increased slightly at the lowest ventilation rate, and other pollutants generally showed very low concentrations, which increased when ventilation was reduced. In no case, however, did levels exceed current health standards for outdoor air, nor was any one contaminant found to be responsible for the medical symptoms reported by occupants. It is possible that a synergistic effect of the various contaminants and environmental conditions could account for the discomfort of occupants.

0445
Turk, B.H., Brown, J.T., Grimsrud, J.T., Geisling-Sobotka, K., Harrison, J., and Revzan, K.L. (1986) "Indoor air quality measurements in 38 Pacific Northwest commercial buildings", Paper 86-5.3, presented at the 79th Annual Meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (26 pages).

KEYWORD: monitor, ventilation, office, indoor, radon, smoking, CH2O, NO2, CO2, particulate

A Bonneville Power Administration-funded study monitored ventilation rates and a variety of indoor air pollutants in 38 Pacific Northwest commercial buildings. The buildings ranged in age from 6 months to 90 years, in size from 864 to 34,280 m^2, and occupancy from 25 to 2,500 people. Building average formaldehyde (CH_2O) concentrations were below the 20 ppb detection limit in 48% of the buildings. Nitrogen dioxide (NO_2) concentration averages ranged from 5 ppb to 43 ppb and were lower than outdoor concentrations in 8 of 13 buildings. At only one site, an elementary school classroom, did carbon dioxide (CO_2) exceed 1,000 ppm. Radon (Rn) levels were elevated in one building with an average concentration of 7.4 $pCiL^{-1}$. Respirable particle (RSP) concentrations in smoking areas in 32 buildings had a geometric mean of 44 ug m^{-3} and ranged up to 308 ug m^{-3} at one site. In non-smoking areas the geometric mean RSP was 15 ug m^{-3}. Outside air ventilation rates did not appear to be the single dominant parameter in determining indoor pollutant concentrations. Measured pollutant concentrations in 2 "complaint" buildings were below accepted guideline. The cause of the complaints was not identified.

0690
Underhill, D.W. (1984) "Efficiency of passive sampling by adsorbents", Am. Ind. Hyg. Assoc. J., 45(5):306-310.

KEYWORD: sampling, monitoring, statistical, personal, exposure, VOC, QA, methodology, monitor

The efficiency of passive samplers can be influenced strongly by the adsorption isotherm. This study calculated sampling efficiency in terms of dimensionless variables for adsorption controlled by the Langmuir, Freundlich, and Dubinin-Radushkevich isotherms. For the latter isotherm, which is often followed by activated charcoal to adsorb solvent vapors, passive sampling may remain highly efficient until a significant fraction of the adsorbent's capacity has been used.

0408
Urban, M., and Kiefer, H. (1985) "Indoor and outdoor natural radiation survey programmes, aspects of instrumentation and organization, results", Sci. Total Environ., 45:281-297.

KEYWORD: radiation, exposure, methodology, literature, foreign, radon, source, Germany

In the last two decades, many countries started national or regional surveys to assess the average exposure of the general public to natural radiation. Survey programs for external radiation as well as for radon and decay products indoors either have been performed, are still in progress, or will be started in the near future. The paper discusses briefly technical and organizational aspects of survey measurements as well as practical experiences and results available from national or regional survey programs.

0339
Van der Kolk, J. (1984) "Wood preservatives and indoor air, experiences in The Netherlands", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 1, recent advances in the health sciences and technology", Swedish Council for Building Research, Stockholm, pp. 251-256. NTIS PB85-104180.

KEYWORD: pesticide,field,health,exposure, wood, control, foreign, Netherlands

The application of wood preservatives in the interior of buildings in The Netherlands has in recent years been shown to be a potential health hazard. A number of experiences indicate that in many cases the application of wood preservatives has not been in accordance with good practice and does not adequately consider the possible health effects for people living in the treated houses. Both preventive and remedial treatments as well as insecticidal and fungicidal products are considered. The Netherlands regulates these products under the Pesticides Act, implying a registration prior to their sale and use.

0353
Van Houdt, J.J., and Boleij, J.S.M. (1984) "Mutagenic activity of indoor airborne particles compared to outdoors", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 169-176. NTIS PB85-104198.

KEYWORD: particulate, health, mutagenicity, exposure, source, smoking

This study deals with the mutagenic activity of indoor samples under normal living conditions in relation to outdoor air. Particles were collected simultaneously in kitchens, living rooms, and outdoors. Methanol extracts were tested in the Salmonella/microsome assay. The mutagenic activity of indoor as well as outdoor samples generally increased in the presence of a metabolizing system. Furthermore, the indoor samples bore higher indirect mutagenic activity, especially in smokers' homes. Kitchen samples also showed mutagenic activity, probably due to volatilization of cooking products. Infiltrated outdoor particles did not contribute to indoor mutagenicity.

0409
Vanmarcke, H., Janssens, A., and Raes, F. (1985) "The equilibrium of attached and unattached radon daughters in the domestic environment", Sci. Total Environ., 45:251-260.

KEYWORD: radon, particulate, ventilation, model, dose, exposure, field, aerosol

The Jacobi Room Model is applied to fit radon daughter concentrations measured in a room. The aerosol size distribution and ventilation rate are measured simultaneously. The mean deposition rate fitted to these experiments is 16 h-1. Once all parameters are fixed, the unattached fraction and the effective dose equivalent are calculated, and compared to the Working Level concept.

0387
Vedel, A., and Nielsen, P.A. (1984) "Phthalate esters in the indoor environment", Berglund, B., Lindvall, T., and Sundell, J., Eds.,"Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 309-314. NTIS PB85-104206.

KEYWORD: phthalate, source, health, literature, field, exposure, outdoor, particulate, architecture

This paper gives an overall evaluation of the actual state of knowledge about phthalates. Phthalate esters have boiling points higher than 250 degrees C., and for that reason have not been studied as an indoor air pollutant. However, phthalates are used in many modern building materials, e.g., floor and wall coverings, paints, and electrical lines. Many toxicological studies have been made on phthalates.

0547
Vimpani, G., McMichael, A., Robertson, E., and Wigg, N. (1985) "The Port Pirie study: a prospective study of pregnancy outcome and early childhood growth and development in a lead-exposed community protocol and status report", Environ. Res., 38:19-23.

KEYWORD: Pb, biomonitoring, sampling, health, children, economic, statistical, demographic, foreign, Australia, pregnancy

The Port Pirie, Australia, environment and pregnancy study was established in 1979 to study the relationship of cumulative postconception Pb exposure to pregnancy outcome and to postnatal growth and development. Of the possible 735 newborns followed since the antenatal period, researchers anticipate that growth/development data will be obtained through the age of 7 years for 600 of these children. Serial measures of blood Pb, and subsequently dental Pb measures, will allow examination of relationships among Pb burden, a range of environmental/social covariates, and developmental data.

0526
Vo-Dinh, Tuan (1983) "A personnel or area dosimeter for polynuclear aromatic vapors", in "proceedings: National symposium on recent advances in pollutant monitoring of ambient air and stationary sources, held at Raleigh, NC, May 4-7, 1982, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 289-300. NTIS PB84-148345.

KEYWORD: pyrene, PAH,phenanthrene,quinoline,QA,personal,exposure, methodology

A new passive dosimeter has been developed for monitoring airborne vapors and liquid aerosols of potentially hazardous polynuclear aromatic compounds. The device is a self-contained, badge-size unit that passively collects on filter paper the compounds to be monitored at a diffusion-controlled rate. Collection is followed by in-situ, room temperature phosphorescence analysis of the compounds adsorbed on the dosimeter. The dosimeter can detect pyrene, phenanthrene, and quinoline at sub-ppb levels for an 8-hour exposure.

0322
Vo-Dinh, Tuan (1985) "Development of a dosimeter for personnel exposure to vapors of polyaromatic pollutants", Environ. Sci. Technol., 19 (10)997-1003.

KEYWORD: PAH, pyrene, phenanthrene, quinoline, personal,exposure, methodology, QA

A new personal dosimeter based on molecular diffusion and direct detection by room temperature phosphorescence (RTP) has been developed to monitor vapors of polynuclear aromatic hydrocarbons (PAH). The dosimeter is a simple, pen-size device that requires no sample extraction for analysis. By proper calibration of the dosimeters, the time-weighted average exposure to the pollutants can be determined directly on the sample collection substrate. The dosimeters can detect a variety of PAH compounds such as pyrene, phenanthrene, and quinoline at 2.5, 0.5, and 0.75 ppb vapor concentrations, respectively, after 1 hour of exposure.

0441
Wade, W.A., III, Cote, W.A., and Yocom, J.E. (June 1974) "A study of indoor air quality" Paper no. 74-50, presented at the 67th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (28 pages).

KEYWORD: NO, NO2, appliance, EPA$, outdoor, exposure, source, CO, field

As part of a larger program to investigate indoor sources of air pollution, an indoor/outdoor sampling program was carried out for NO, NO2, and CO in three homes with gas stoves. The study houses represented different surrounding land use, life styles, and house age and layout. The pollutant gases were measured essentially simultaneously at three indoor locations and one outdoor location by single multiplexed NO-NO2 and CO instruments that used a sample switching system. The results thus far show that indoor levels of NO and NO2 are directly related to stove use in the homes tested. Furthermore, these stoves often produced more NO2 than NO, and average levels of NO2 in the kitchen could exceed 100 ug/m3. Indoor CO concentrations appeared to be influenced more by outdoor activities (automotive traffic) than by indoor sources. In a diffusion experiment conducted in one home, the half-life for NO2 was less than one-third that for either NO or CO. Oxidation of NO to NO2 (based on comparing the half-life of NO to CO) does not appear to occur to a significant degree indoors.

0655
Wade, W.A., III, Cote, W.A., and Yocum, J.E. (Sept. 1975) "A study of indoor air quality", J. Air Pollut. Control Assoc., 25(9):933-939.

KEYWORD: NO2, NO, CO,home,outdoor, field,EPA$, appliance, source, exposure

As part of a larger program to investigate indoor sources of air pollution, NO, NO2, and CO were monitored in four private houses with gas stoves. The four houses chosen for study represented different surrounding land use, life styles, and house age and layout. The gases were measured essentially simultaneously at three indoor locations and one outdoor location. The results showed that indoor levels of NO and NO2 are directly related to stove use in the homes tested. Furthermore, the stoves often produced more NO2 than NO. In some instances, the levels of NO2 and CO in the kitchen exceeded the air quality standards for these pollutants outdoors. The data for the sampling periods were typical of an entire year. A diffusion experiment conducted in one of the houses showed that the half-life for NO2 was less than one-third that for either NO or CO. Oxidation of NO to NO2 (based upon comparing the half-life of NO to CO) does not appear to occur to a significant degree indoors.

0715
Walker, Muriel V., and Weschler, Charles J. (1980) "Water-soluble components of size-fractionated aerosols collected after hours in a modern office building", Environ. Sci. Tech., 14(5):594-597.

KEYWORD: office, aerosol, particulate, outdoor, SO4, NH4, NO3, Na, chloride

Size-fractionated aerosol samples were collected after hours in a modern six-story office building with approximately 4,000 employees. The total water-soluble content of the aerosol decreases with increasing particle size, as indicated by conductivity measurements. Sulfate and ammonium are chiefly responsible for this trend, while nitrate, chloride, and sodium are fairly evenly distributed throughout the size-fractionated samples. Indeed, acid ammonium sulfate accounts for the majority of the water-soluble material in the submicron aerosol. In this size range, the indoor sulfate values are very similar to reported outdoor values. The results suggest that, consistent with the building's air filtration system, the gross features of the indoor and outdoor aerosols in the submicron size range are similar, while differences are more pronounced in the larger size ranges.

0127
Wallace, L., Pellizzari, E., Hartwell, T., Sparacino, C., Sheldon, L., and Zelon, H. (1984) "Personal exposures, outdoor concentrations, and breath levels of toxic air pollutants measured for 425 persons in urban, suburban, and rural areas", Paper no. 84-1.8, presented at the 77th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (18 pages).

KEYWORD: VOC, outdoor, TEAM, personal, exposure, water, EPA$, field, QA, biomonitoring

EPA's Total Exposure Assessment Methodology (TEAM) study measured exposures to 20 volatile organic compounds in personal air, outdoor air, drinking water, and breath of 370 persons in New Jersey, 25 in North Dakota, and 30 in North Carolina during 1980-82. The New Jersey residents were selected by a probability sampling scheme to represent 120,000 inhabitants of Elizabeth and Bayonne. Participants carried a personal monitor to collect two 12-hour outdoor air samples and gave a breath sample at the end of the day. Two consecutive 12-hour outdoor air samples were also collected on identical Tenax cartridges in the backyards of 90 of the participants. About 3,000 samples were collected, of which 1,000 were quality control samples. Eleven compounds were often present in the air. Personal exposures were invariably higher than outdoor concentrations for these chemicals, sometimes 10 times higher. Indoor sources appeared responsible for much of the differences. Breath concentrations also usually exceeded outdoor concentrations, and correlated more strongly with personal exposures than with outdoor concentrations.

0004
Wallace, L., Pellizzari, E., Hartwell, T., Perritt, K., and Ziegenfus, R. (in press) "Exposures to benzene and other volatile compounds from active and passive smoking",Arch. Environ. Health.

KEYWORD: aromatic,benzene,biomonitoring,VOC, exposure,field,home, monitor,TEAM,smoking,office,source,statistical,EPA$,outdoor

Personal exposures and breath concentrations of approximately 20 volatile organics were measured for 200 smokers and 322 nonsmokers in New Jersey and California. Smokers had significantly elevated breath levels of benzene, styrene, ethylbenzene, m+p-xylene, o-xylene, and octane. The first four aromatic compounds increased significantly with the number of cigarettes smoked. Based on direct measurements of benzene in cigarette smoke, calculations show that a typical smoker is exposed to 2 mg benzene/day, compared to 0.2 mg/day for the nonsmoker. Thus, cigarette smoking is the most important source of exposure to benzene for about 50 million U.S. citizens. Passive smokers exposed at work had significantly elevated levels or aromatics in their breath. Indoor levels increased significantly in homes with smokers in some measurement groups but not in others. The average increase for benzene was 3.6 ug/m3, and for styrene , 0.5 ug/m3, about a 50% relative increase in each case. Thus, exposure to benzene and styrene may increase for the approximately 60% of children and other nonsmokers living in homes with smokers.

0126
Wallace, L., Zweidinger, R., Erickson, M., Cooper, S., Whitaker, D., and Pellizzari, E.D. (1982) "Monitoring individual exposure: measurements of volatile organic compounds in breathing zone air, drinking water and exhaled breath", Environ. Int., 8:269-282.

KEYWORD: methodology, water, biomonitoring, field, statistical, personal, exposure, EPA$, VOC

Methods for determining individual exposure to volatile organic compounds (VOCs) during normal daily activities were field tested on university student volunteers in Texas and North Carolina. The equipment tested included a personal exposure monitor (PEM) employing Tenax GC to collect organic vapors for later analysis by gas chromatography/mass spectrometry, and a specially designed spirometer for collecting samples of expired human breath on duplicate Tenax cartridges. The PEM and spirometer proved feasible for collecting abundant quantitative data on most of the 15 target organics. Exposures to many VOCs in air varied widely, sometimes over three orders of magnitude, among students of the same campus who had been monitored at the same time. A log-linear relationship between breathing-zone air exposures and concentrations in exhaled breath was suggested for three chemicals: tetrachloroethylene, 1,1,1-trichloroethane, and vinylidene chloride. Air was the main route of exposure for all target compounds except for chloroform and bromodichloromethane, which were transmitted mainly through water. Estimated total daily intake through air and water of the target organics was 0.3 to 12.6 mg, with 1,1,1-trichloroethane at the highest concentrations in both geographic areas.

0051
Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., and Zelon, H. (June 1983) "Personal exposure to volatile organics and other compounds indoors and outdoors -- the TEAM study", Paper no. 83-9.12 presented at the 76th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (29 pages).

KEYWORD: VOC, field, water, outdoor, personal, exposure, TEAM, distribution, biomonitoring, EPA$, activity

As part of the Total Exposure Assessment Methodology (TEAM) study, individual 24-hour exposures to 18 volatile organic compounds were measured for 375 randomly selected volunteers in Bayonne and Elizabeth, NJ, in the fall of 1981. Two 12-hour air samples and two drinking water samples were collected and analyzed for each volunteer. Two 12-hour backyard air samples were also collected for a subset of 100 subjects. Exhaled breath samples were taken at the end of the 24-hour period. Subjects kept diaries detailing their activites during the monitoring period. Comparisons of outdoor concentrations with personal exposures show large variations for many chemicals. Correlations between chemical concentrations in air, drinking water, and exhaled breath show that for some chemicals, breath measurements may be useful as indicators of previous exposure. Frequency distribution of exposures is estimated for the entire population of the two-city area based on the 375-person sample.

0719
Wallace, L.A., and Pellizzari, E.D. (1986) "Personal air exposures and breath concentrations of benzene and other volatile hydrocarbons for smokers and nonsmokers", Toxicol. Lett., 35:113-116.

KEYWORD: smoking, biomonitoring, VOC, exposure,field,hydrocarbon, seasonal,aromatic, EPA$, personal

Personal air exposures and exhaled breath concentrations of 20 volatile organic compounds were measured for 198 smokers and 322 nonsmokers in five U.S. cities: Bayonne and Elizabeth, NJ; Los Angeles, CA; and Antioch and Pittsburgh, PA (1980-84). Smokers showed significantly increased breath concentrations of six hydrocarbons: benzene, styrene, ethylbenzene, o-xylene, m+p-xylene, and octane. During fall and winter, homes with smokers had higher indoor air concentrations of the same compounds than homes without smokers. Nonsmokers exposed at work had significantly higher levels of benzene and other aromatics in their breath than unexposed nonsmokers.

0145
Wallace, Lance (Nov. 1984) "Do buildings make people sick?", Paper presented at the symposium of the American Institute for Architects held in San Francisco, CA. U.S. EPA, Office of Research and Development, Washington, DC 20460 (11 pages). Not available from NTIS.

KEYWORD: CO, NO2, radon, particulate, VOC,architecture,pesticide, EPA$

This paper discusses the "sick building syndrome" and pollutants that contribute to this problem. The important pollutants discussed are radon, respirable particles, volatile organics, pesticides, NO2, and CO. Examples of levels of specific pollutants measured in buildings and private homes are given, and alternative corrective measures are suggested. This design-oriented article is directed toward architects.

0282
Wallace, Lance A. (1983) "Carbon monoxide in air and breath of employees in an underground office", J. Air Pollut. Control Assoc., 33(7):678-682.

KEYWORD: CO, methodology, personal, exposure, source, control, method, biomonitoring, EPA$, office, smoking

An office containing about 65 employees was found to have 8-hour average CO concentrations of 18 to 26 ppm during a week in winter. On one Friday afternoon, 20 nonsmoking office workers had alveolar CO levels of 23 (+/- 3) ppm compared to levels of 8 (+/- 2) ppm in six nonsmoking workers in other offices in the same building. After a weekend at home, the affected office workers had alveolar CO levels of 7 (+/- 2) ppm. The source of the high CO levels was attributed to a parking garage on the same level as the office. Closing fire doors and activating garage fans rectified the situation. The breath sampling method required a correction factor based on the difference between the true alveolar CO and the CO level in the surrounding air. The methods and equipment employed in this study (personal air monitors, electronic data loggers, breath sampling) are recommended for screening and identifying potential CO problems in buildings with similar conditions.

0497
Wallace, Lance A. (in press) "Personal exposures, indoor and outdoor air concentrations, and exhaled breath concentrations of selected volatile organic compounds measured for 600 residents of New Jersey, North Dakota, North Carolina and California", Toxicol. Environ. Chem.

KEYWORD: VOC, outdoor, exposure, personal, source, field, water, QA, TEAM, biomonitoring, EPA$, smoking, styrene, benzene

EPA's Total Exposure Assessment Methodology (TEAM) study has measured exposures to 20 volatile organic compounds in personal air, outdoor air, drinking water, and breath of 600 residents of

New Jersey, North Carolina, North Dakota, and California. Participants in the study were selected in such a way as to represent 700,000 inhabitants of seven cities. Participants carried a personal monitor that collected two 12-hour air samples and gave a breath sample at the end of each day. Two consecutive 12-hour outdoor air samples were also collected on identical Tenax cartridges in the backyards of some of the participants. Researchers collected 7,500 samples (2,000 of which were quality-control samples) and frequently found 11 compounds in the air samples. Personal exposures were consistently higher than outdoor concentrations, and indoor sources appeared to be responsible for the higher concentrations. Some activities (such as smoking or visiting dry cleaners or service stations) and occupations (involving chemical, paint, and plastics plants) were associated with significantly elevated exposures and breath levels for certain toxic chemicals. Residing near major point sources, however, did not affect exposure.

0437
Wallace, Lance A., et al. (in press) "California TEAM study: breath concentrations and personal exposures to 26 volatile compounds in air and drinking water of 188 residents of Los Angeles, Antioch, and Pittsburg, California", Atmos. Environ.

KEYWORD: TEAM, VOC, personal, exposure,outdoor,water, EPA$,field, biomonitoring, smoking, vehicle, statistical, halocarbon

In 1984, EPA's Total Exposure Assessment Methodology (TEAM) study measured personal exposures to 26 volatile organic chemicals in the air, drinking water, and exhaled breath of 188 California residents. Often, 16 chemicals were found above quantifiable limits in the personal air samples, but only four trihalomethanes were found in drinking water. The highest exposures were to 1,1,1-tetrachloroethylene. Indoor air concentrations generally exceeded outdoor concentrations, particularly at the higher percentiles. Breath concentrations of eight chemicals showed significant correlations with preceding personal air concentrations in the two visits to Los Angeles. Smoking, employment, and automobile-related activities were identified as important sources of personal exposure to the target compounds.

0136
Wallace, Lance, et al. (1984) "Personal exposure to volatile organic compounds -- 1. direct measurements in breathing-zone air, drinking water, food, and exhaled breath", Environ. Res., 35:293-319.

KEYWORD: VOC, field, personal, exposure, biomonitoring, food, methodology, water, EPA$

A pilot study to test methods of estimating personal exposures to toxic substances and corresponding body burdens was carried out from July to December 1980. Individual exposures to about a dozen volatile organic compounds in air and drinking water were measured for nine volunteers in Bayonne and Elizabeth, NJ, and for three volunteers in Research Triangle Park, NC, during three 3-day visits over the 6-month period. Breath samples were also collected from all subjects on each visit. Composite food samples were collected in each locality. Sampling and analytical methods for air, water, food, and breath were evaluated and found generally capable of detecting concentrations as low as 1 ug/m3 in air and breath, and 1 ng/m3 in water and food. About 230 personal air samples, 170 drinking water samples, 66 breath samples, and 4 food samples (16 composites) were analyzed for the target chemicals. Probable exposure routes are discussed in detail.

0336
Wallace, L., Bromberg, S., Pellizzari, E., Hartwell, Ty, Zelon, H. and Sheldon, L. (1984) "Plan and preliminary results of the U.S. Environmental Protection Agency's indoor air monitoring program: 1982", Berglund, B., Lindvall, T., and Sundell, J., Eds. "Indoor air, vol. 1, recent advances in the health sciences and technology", Swedish Council for Building Research, Stockholm, pp. 173-178. NTIS PB85-104180.

KEYWORD: school, outdoor, field, VOC, PCB,particulate,CH2O, home, pesticide,office,smoking,exposure,EPA$,ventilation,seasonal

EPA initiated an indoor air monitoring program in 1982, concentrating on commercial or public-access buildings (homes for the elderly, schools, and office buildings). Several buildings from each category were sampled over 2- to 3-day periods for volatile organics, respirable particulates, formaldehyde, pesticides, PCBs, and other pollutants. Simultaneous outdoor air samples and tracer gas samples were taken to determine outdoor-indoor ratios and air exchange rates. One new building from each category was sampled intermittently for 1 year to determine temporal trends in the indoor concentrations of organics. Preliminary results from the first building sampled are presented. Broad-spectrum analyses for organics identified 350 chemicals in indoor air in the home for the elderly. Indoor concentrations of 10 volatile organic chemicals exceeded outdoor concentrations by 50 to 100%. Smoking increased 24-hour fine particulate (< 2.5 um) concentrations by 20 to 30 ug/m3, with associated short-term peaks of 300 ug/m3.

0429
Wallace, L., et al. (1986) "Concentrations of 20 volatile organic compounds in the air and drinking water of 350 residents of New Jersey compared with concentrations in their exhaled breath", J. Occup. Med., 28(8):603-608.

KEYWORD: personal, field,EPA$, water, biomonitoring, statistical, exposure, TEAM, VOC, methodology, outdoor, sampling

Twenty volatile organic compounds were measured in the personal air and drinking water of 350 New Jersey residents in the fall of 1981. Two consecutive 12-hour integrated personal air samples and two tap water samples were collected from each participant. At the end of the 24-hour monitoring period, each participant supplied a sample of exhaled breath. Simultaneous outdoor samples were collected in 100 residential locations in two cities. Eleven compounds were present much of the time in air, but only four (the trihalomethanes) in water; wide ranges of exposures (three to four orders of magnitude) were noted for most compounds. Ten of 11 compounds displayed significant correlations between air exposures and breath concentrations; the 11th compound (chloroform) was correlated with drinking water exposures. Researchers concluded that breath measurements are a feasible, cost-effective, and highly sensitive way to determine environmental and occupational exposures to volatile organic compounds.

0087
Wallace, L.A., Pellizzari, E., Leaderer, B., Zelon, H., and Sheldon, L. (1987) "Emissions of volatile organic compounds from building materials and consumer products", Atmos. Environ., 21:385-393.

KEYWORD: VOC, TEAM, source, personal, home, activity, emission, office, industrial, exposure, EPA$, architecture

EPA's Total Exposure Assessment Methodology (TEAM) study of personal exposure to volatile organic compounds (VOC) in air and drinking water identified many possible sources encountered in peoples' normal activities and homes. A follow-up EPA study of public-access buildings implicated other potential sources of exposure. To learn more about these potential sources, 15 building materials and common consumer products were analyzed using a gas chromatography/mass spectrometry headspace technique to detect organic emissions and to compare relative amounts. About 10 to 100 organic compounds were being emitted from each material. For some chemicals, measured levels could account for a significant fraction of the elevated concentrations observed in previous indoor air studies. Common materials found in nearly every home and place of business may elevate exposures to toxic chemicals.

0018
Wallace, L.A., Pellizzari, E.D., Hartwell, T.D., Sparacino, C., and Zelon, H. (1983) "Personal exposure to volatile organics and other compounds indoors and outdoors -- the TEAM study", U.S. EPA, Office of Research and Development, Washington, DC 20460 (35 pages). NTIS PB83-231357.

KEYWORD: VOC, biomonitoring,sampling, design, personal, exposure, outdoor, EPA$, methodology, field, statistical

The major objective of this study is to develop and field test a methodology for measuring individual human exposure to toxic substances. A secondary objective is to develop methods for estimating body burden with the use of biological measurements. All significant pathways of exposure are addressed. In Phase 1 of the study, sampling and analytical protocols were tested for volatile organic compounds, organochlorine pesticides, metals, and polyaromatic hydrocarbons. In Phase 2, exposure through air and drinking water and excretion rates through inhaled breath were measured for a statistically valid sample population. It was determined that personal air median concentrations ranged from 40 to 320% higher than outdoor fixed air concentrations. Correlations between personal and outdoor samples were poor. It was concluded that personal air, indoor air, or breath measurements are far superior to outdoor measurements for estimating exposure. The study is currently entering its third phase.

0487
Wallace, L.A., Pellizzari, E.D., and Gordon, S.M. (1985) "Organic chemicals in indoor air: a review of human exposure studies and indoor air quality studies", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds., "Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI 48118, pp. 361-378.

KEYWORD: TEAM, halocarbon, personal, exposure,VOC, outdoor, home, smoking, source, field, EPA$, regulation

This paper reviews several major studies concerning the concentrations of volatile organic compounds (VOCs) in homes and public buildings. EPA's Total Exposure Assessment Methodology (TEAM) study determined 12-hour integrated exposures and corresponding breath levels of 20 to 25 target VOCs in 650 households in six cities (Bayonne and Elizabeth, NJ; Greensboro, NC; Devils Lake, ND; and Los Angeles and Antioch, CA). The TEAM study indicated that personal air exposures were greater than outdoor air concentrations. The halocarbon study determined 12-hour integrated exposures to 20 to 30 halogenated hydrocarbons in 150 households in Baton Rouge, LA; Houston, TX; and Greensboro, NC. The results confirmed the conclusion that indoor levels of nearly all common target chemicals are higher than outdoor levels. Seven other VOC studies are briefly discussed. VOC sources are summarized.

0015
Wallace, Lance A. (1981) "Recent progress in developing and using personal monitors to measure human exposure to air pollutants", Environ. Int., 5:73-75.

KEYWORD: particulate, CO, vinyl,personal,exposure, monitor, EPA$, NO2, literature, VOC

Within the last 2 years, great progress has been made in the field of personal air quality monitors. Improvements in pump design, miniaturization, adsorption techniques, and new collection principles have produced about a dozen sensitive monitors capable of being used by the general public to measure their normal everyday exposure to many toxic or carcinogenic compounds. Field-tested personal exposure monitors for volatile organics, inhalable particulates, CO, NO2, and vinyl chloride are briefly summarized.

0474
Wallace, Lance A. (1982) "Measuring direct individual exposure to toxic substances", Tox. Subst. J., 4(3):174-183.

KEYWORD: personal, exposure, monitor, EPA$, methodology, TEAM, biomonitoring, literature, field, research

Recent technological advances have made it possible to directly measure a person's exposure to toxic substances through all major pathways (air, food, water). Other described advances include those that make it possible to measure the same toxic substances as they are absorbed, exhaled, or stored by the body. The concept of using these advances to measure total exposure is also discussed and illustrated, by reference, to ongoing research. Finally, the author outlines major areas where further work is needed.

0061
Wallace, Lance A. (June 1979) "Use of personal monitor to measure commuter exposure to carbon monoxide in vehicle passenger compartments", Paper no. 79-59.2, presented at the 72nd annual meeting of the Air Pollution Control Association, P.O. Box 2861,

Pittsburgh, PA 15230 (15 pages).

KEYWORD: CO, statistical,ventilation, vehicle,interior, personal, exposure, monitoring, EPA$

Exposure to CO while commuting to and from Washington, DC, was measured for 4 weeks during the summer of 1978 using a personal exposure monitor. Mean exposure level was 11.7 (+/- 4.9) ppm. Air-conditioned buses had interior CO concentrations 60% higher than non-air-conditioned buses. City driving increased CO exposures by 50%. Little correlation (r = 0.1) was noted between ambient levels and commuter exposures; the more important variable appeared to be whether the particular vehicle had air conditioning. Variations in exposure aboard a single bus were small; interbus variations were larger. One defective bus (interior levels 100 ppm) was encountered.

0438
Wallace, Lance A., et al. (1984) "Analysis of exhaled breath of 355 urban residents for volatile organic compounds", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 15-20. NTIS PB85-104214.

KEYWORD: TEAM, VOC, personal, source, water, monitor, exposure, EPA$, biomonitoring, field, statistical, outdoor, sample

EPA's Total Exposure Assessment Methodology (TEAM) study measured personal exposures to 19 volatile organic compounds in air and drinking water of 355 residents of Elizabeth and Bayonne, NJ. Subjects were selected from a two-stage probability design to be representative of the entire population (122,000) of the two cities. Personal monitors (Tenax-GC cartridges) collected two consecutive 12-hour samples of breathing-zone air for each participant. A drinking water sample was also collected from each person. Outdoor air samples were collected from 90 participants' backyards. At the end of the 24-hour monitoring period, a breath sample was collected from each participant. All samples were analyzed using gas chromatography/mass spectrometry computerized techniques. Of the target compounds, 11 (chloroform, 1,1,1-trichloroethane, benzene, styrene, o-xylene, carbon tetrachloride, m/p-xylene, m/p-dichlorobenzene, ethylbenzene, trichloroethylene, and tetrachloroethylene) showed consistently high concentrations in personal air and breath samples than in outdoor samples. This indicates that indoor sources of all these chemicals are prevalent and more effective in delivering a dose than outdoor sources. The researchers concluded that breath analysis is useful in identifying and quantifying previous exposures, and in detecting increased exposures due to indoor sources and personal activities.

0285
Wallace, Lance A., et al. (in press) "The TEAM study: personal exposures to toxic substances in air, drinking water, and breath of 400 residents of New Jersey, North Carolina, and North Dakota", Environ. Res.

KEYWORD: VOC, TEAM, personal, exposure, monitor, source, smoking, field, benzene, outdoor, styrene, EPA$, water, biomonitoring, QA

EPA's Total Exposure Assessment Methodology (TEAM) study has measured exposures to 20 volatile organic compounds in personal air, outdoor air, drinking water, and breath of 400 residents of New Jersey, North Carolina, and North Dakota. Participants carried a personal monitor to collect two 12-hour air samples and gave a breath sample at the end of the day. Two consecutive 12-hour outdoor air samples were also collected on identical Tenax cartidges in the backyards of some of the participants. About 5,000 samples were collected, of which 1,500 were quality control samples. Ten compounds were often present in personal air and breath samples at all locations. Personal exposures were consistently higher than outdoor concentrations for these chemicals, sometimes 10 times higher. Indoor sources appeared responsible for much of the difference. Breath concentrations also often exceeded outdoor concentrations, and correlated more strongly with personal exposures than with outdoor concentrations. Some activities (smoking, visiting dry cleaners or service stations) and occupations (chemical, paint, and plastics plants) were associated with significantly elevated exposures and breath levels for certain toxic chemicals. Homes with smokers had significantly increased benzene and styrene levels in indoor air. Living near major point sources did not affect exposure.

0016
Wallace, Lance A., and Ott, Wayne R. (1982) "Personal monitors: a state-of-the-art survey", J. Air Pollut. Control Assoc., 32(6):601-610.

KEYWORD: field,personal, exposure, monitor,PAH,radon,VOC,SOx,NOx, halocarbon,particulate,O3,metal,methodology,laboratory,EPA$

Recent advances in technology have resulted in development of a number of small lightweight devices that can be carried by a person throughout the day to record personal exposure to selected air pollutants. The essential characteristics, advantages, and problems associated with personal monitors are discussed and compared to the characteristics of fixed-station monitoring. Personal monitors generally are superior to fixed monitors for estimating pesonal exposure, at least for selected air pollutants, They permit collecting data on pollutant concentrations that people normally come into contact with throughout their daily activities-- indoors, outdoors, and in various modes of transportation. These new instruments ultimately could transform how human exposure to air pollution is estimated.

0209
Wallace, Lance A., and Ziegenfus, Robert C. (1985) "Comparison of carboxyhemoglobin concentrations in adult nonsmokers with ambient carbon monoxide levels", J. Air Pollut. Control Assoc., 35(9):944-949.

KEYWORD: CO, biomonitoring, QA, outdoor, laboratory, statistical, analysis, risk, assessment, EPA$, smoking

Blood samples from several thousand current nonsmokers were collected by the National Center for Health Statistics between 1976 and 1980 in the Second National Health and Nutrition Evaluation Survey (NHANES II). The blood samples were analyzed for carboxyhemoglobin (COHb) using highly sensitive techniques by two laboratories under rigorous quality control procedures. COHb levels of 1528 persons were compared to the immediately preceding 1-hour and 8-hour ambient CO averages in 20 U.S. cities. Spearman rank correlation coefficients between COHb and ambient CO were not significant for a large majority of fixed-monitoring stations in the 20 cities. No improvement was shown when the comparisons were limited to central-city residents. A regression of all 1528 COHb levels on the most predictive ambient stations in each city indicated that 3% of the variance in COHb levels was explained by the fixed stations. Therefore, fixed outdoor CO monitors are not, in general, providing useful estimates of CO exposures of urban residents. Attempting to protect public health by setting an outdoor standard for CO may be inappropriate.

0592
Wallace, Lance. A. (1985) "Organics overview", Gammage, R.B., Kaye, S.V., and Jacobs, V.A., Eds.,"Indoor air and human health", Lewis Publishers, Inc., P.O. Drawer 519, Chelsea, MI, pp. 331-333.

KEYWORD: VOC,personal,exposure,health, methodology, architecture, source, regulation, EPA$

Because organic pollutants may cause cancer, they are feared constituents of chemical and industrial emissions (Cancer Alley, NJ) and hazardous waste dumps (Love Canal, NY). Multibillion -

dollar Federal programs, such as Superfund and National Emission Standards for Hazardous Air Pollutants (NESHAPS), have been initiated to regulate the sources. However, recent studies have implicated the indoor environment as another major and possibly more important source of organic pollutants. If corroborated, the findings will have profound implications for builders, regulators, and researchers.

0379
Wallach, Charles (1984) "Video display health hazard safeguards", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 3, sensory and hyperactivity reactions to sick buildings", Swedish Council for Building Research, Stockholm, pp. 169-174. NTIS PB85-104206.

KEYWORD: particulate, exposure, health, epidemiology,statistical, ion, video, EPA$, control

Recent scientific and popular literature contains many references to the real and purported health hazards to which video display terminal (VDT) operators are exposed. The popular press has dwelled on the hazards with little emphasis on means of prevention. The authors review the real symptoms and suspected causes and discuss correlations with exposure duration and frequency on the basis of large, statistical samplings of VDT operators. State-of-the-art safeguards and countermeasures are presented as practical, economical alternatives to the costly, draconian emergency measures that are now being widely adopted to protect VDT operators from the short- and long-term effects of VDT Operators' Distress Syndrome.

0600
Walsh, Phillip, Killough, George, and Rohwer, Paul (1978) "Composite hazard index for assessing limiting exposures to environmental pollutants: formulation and derivation", Environ. Sci. Technol., 12(7):799-802.

KEYWORD: exposure, dose, risk, microenvironment, multipollutant, health, multimedia, model

A calculational hazard index methodology was developed for limiting human exposure to environmental pollutants. The index is defined as Q/L, where Q is a measure of exposure, such as an organ's burden of a pollutant from all environmental pathways, and L is a corresponding limit that should not be exceeded because of health risks to human beings. Mathematical formulations relating hazard indices to environmental pollutant concentrations were developed for each sampling medium corresponding to each effluent mode. These formulations were used to derive limiting pollutant concentrations such that the resultant measure of exposure will not exceed the health risk limit. Mathematical formulations for composite hazard indices for multiple pollutants are presented.

0206
Wang, J., Cao, S., Li, Z., Zhong, Y., and Li, S. (1985) "Human exposure to carbon monoxide and suspended particulate matter in Beijing, People's Rep. of China", PEP/85.11, World Health Organization, Geneva, Switzerland (69 pages).

KEYWORD: particulate, personal, exposure, monitor, outdoor, home, microenvironment, seasonal, foreign, China, CO

Exposure to CO and respirable particulate matter (RSP) was measured in 1984-85 with 21 volunteers living in three common types of housing in Beijing, People's Republic of China. The volunteers kept activity diaries and carried personal exposure monitors for 1 week in summer and 1 week in winter. Some common public areas were monitored simultaneously. CO and RSP levels were higher in winter than in summer. CO levels were higher indoors than outdoors and vice versa for RSP levels.

0772
Wang, Y.Y., Webber, L.M., Flessel, C.P., Chang, K., Sexton, K., and Sextro., R.G. (1985) "Detection of mutagens in particle and vapor emissions from major indoor sources", Paper no. 85-36.3, presented at the 78th annual meeting of the Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230 (15 pages).

KEYWORD: smoking,risk,home,laboratory,health, combustion, source, particulate, VOC, mutagenicity, appliance

The Ames test using Salmonella typhimurium and mammalian enzymes is widely accepted for screening the mutagenic potential of particulate organic matter (POM) in outdoor air. However, the mutagenicity of vapor-phase organics (VPO) has not been fully assessed. Only a few studies of indoor POM are available. This paper explores the possibility of detecting POM and VPO mutagens from indoor air pollution sources using modified Ames procedures. A pilot chamber study was initiated to characterize particle and vapor emissions from a gas range, cigarette smoking, hamburger frying, antiperspirant spray, and household dusting/polishing spray. Modified Ames procedures were effective for both POM and VPO mutagens from indoor air pollution sources. Combustion products from the gas range, tobacco smoke, and hamburger frying contained mutagens. Cigarette emissions appear to contain more mutagens in VPO than POM. Further chemical analysis and toxicological studies are required to characterize and evaluate the potential health hazards posed by indoor air pollution sources.

0370
Wanner, H.U., and Kuhn, M. (1986) "Indoor air pollution by building materials", Environ. Int., 12(1-4):311-315.

KEYWORD: source, CH2O, ventilation, exposure, regulation

Due to better insulation and improved airtightness of doors and windows, the supply of fresh air entering a room has been greatly reduced. This, in turn, causes an increase in the amount of pollutants emitted by different insulation and building materials. Measurements of the formaldehyde concentration in new buildings have shown that the admissible limits are still exceeded even after a year. Stricter regulations limiting the emissions of pollutants are, therefore, urgently necessary.

0410
Ware, J.H., Dockery, D.W., Spiro, A., III, Speizer, F.E., and Ferris, F.G., Jr. (1984) "Passive smoking, gas cooking, and respiratory health of children living in six cities", Am. Rev. Respir. Dis., 129:366-374.

KEYWORD: smoking, source, exposure, children, combustion, health, statistical, epidemiology, lung, appliance

As part of a longitudinal study of the respiratory health effects of indoor and outdoor air pollutants, pulmonary function, respiratory illness history, and symptom history were recorded at two successive annual examinations of 10,106 white children living in six U.S. cities. Parental education, medical history, and smoking habits also were recorded, along with the fuel used for cooking in the home. Maternal cigarette smoking was associated with increases of 20 to 35% in the rates of eight respiratory illnesses and symptoms investigated, and paternal smoking was associated with smaller but still substantial increases. Illness and symptom rates were linearly related to the number of cigarettes smoked by the child's mother. Illness rates were higher for children of current smokers than for children of ex-smokers. The associations between maternal smoking status and childhood respiratory illnesses and symptoms were reduced but not eliminated by adjustment for parental medical history.

0541
Wedding, J.B., Lombardi, D.J., and Cermak, J.E. (1977) "A wind tunnel study of gaseous pollutants in city street canyons", J. Air Pollut. Control Assoc., 27(6):557-566.

KEYWORD: exposure, regulation, outdoor, vehicle, source, model, microenvironment, laboratory, weather, office

A 400:1 scale model of an idealized city was developed to measure steady-state mean concentrations of tracer gas. The model was placed in a wind tunnel, and tracer gas was released from two parallel line sources to simulate lanes of traffic in an effort to quantify the persistence of pollution as well as the mean values realized at street levels. Values of concentrations measured in the model city were converted to prototype ppm concentrations and compared to National Ambient Air Quality Standards. Single, isolated structures may cause favorable mixing of pollution downwind, but very high concentrations exist in the immediate leeward vicinity of a building. The study provides order-of-magnitude estimates of pedestrian and office worker exposure pollutants under a wide range of conditions.

0653
Wendel, G.J., Stedman, D.H., Cantrell, C.A., and Damrauer, L. (1983) "Luminol based nitrogen dioxide detector", Anal. Chem., 55:937-940.

KEYWORD: NO, NO_x, monitor

An instrument is described for continuous detection of NO_2 in the subppb range. The instrument is based upon the chemiluminescent reaction in air between NO_2 and luminol (5-amino-2,3-dihydro-1,4-phthalazinedione) in alkaline solution. It exhibits a 2-Hz response speed to changes of + or - 20 ppb and a field detection limit of 30 parts per trillion. The limit may be improved by using a better photomultiplier tube as well as further optimizing the cell design. The technique has been expanded to measure NO by the catalytic oxidation of NO to NO_2 using CrO_3 on silica gel as the oxidizing agent; however, at low ambient NO concentrations it is difficult to zero the detector. Interference from ambient O_3 is eliminated by modifying the inlet system and luminol solution.

0496
Weschler, Charles J. (1984) "Indoor-outdoor relationships for nonpolar organic constituents of aerosol particles", Environ. Sci. Technol., 18(9):648-652.

KEYWORD: nicotine,particulate,aerosol,field,sampling, laboratory, halocarbon,ester,outdoor,arkane,methodology,multipollutant,office

Automatic dichotomous samplers (virtual impactors) were used to collect fine (nominally less than 2.5 um in diameter) and coarse (nominally 2.5 to 15 um in diameter) particles inside office buildings at Wichita, KS, and Lubbock, TX. Outdoor samples were collected at the same time. The loaded Teflon membrane filters were then analyzed for nonpolar organic compounds by thermal desorption-gas chromatographic/mass spectrometric procedures. The nonpolar species associated with the outdoor samples are high-molecular-weight n-alkanes. The nonpolar compounds associated with the indoor particles include n-alkanes; branched alkanes; phthalate, phosphate, and azelate esters; chlorofluorocarbons; and nicotine. Typical concentrations for nonpolar organic constituents of indoor particles are much higher than for those of outdoor particles. With the exception of selected n-alkanes, each of the detected nonpolar organic compounds comes primarily from indoor sources. Adsorption of organic compounds onto the surface of airborne particles probably is more significant indoors than outdoors.

0495
Weschler, Charles J. (1978) "Characterization techniques applied to indoor dust", Environ. Sci. Technol., 12(8):923-926.

KEYWORD: NO2, particulate,office,hydrocarbon,organic,methodology, laboratory, K, Ca, Cl, SO4, NO3, Na

Methods of characterizing dusts found within buildings were studied, using samples collected in Bell Laboratories' facility at Holmdel, NJ. Particle size and morphology were determined by optical scanning electron microscopy. C, H, and N were analysed quantitatively, and elements with atomic numbers greater than 10 were analysed semiquantitatively, by energy-dispersive x-ray spectroscopy. Water-soluble Cl, SO4, NO3, Na, K, and Ca were determined using specific ion electrodes and energy dispersive x-ray spectroscopy. The specific conductances of water extracts were measured. The principal elements present in the benzene-soluble components were identified, and the organic functional groupings of these materials were examined by infrared spectroscopy.

0357
Weschler, Charles J., and Fong, Karen L. (1986) "Characterization of organic species associated with indoor aerosol particles", Environ. Int. 12(1-4):93-97.

KEYWORD: particulate, aerosol,outdoor,office, field, hydrocarbon, smoking,multipollutant,halocarbon,laboratory,nicotine,ester

Automatic dichotomous samplers collected fine and coarse particles inside office buildings in the central region of the United States. Outdoor samples were collected at the same time. Samples were analyzed for both nonpolar organic compounds and fatty acids. The former were characterized by thermal desorption-gas chromatographic/mass spectrometric procedures. The latter were solvent extracted, methylated, and identified by gas chromatography/mass spectrometry. The nonpolar compounds associated with the indoor particles included n-alkanes; branched alkanes; phthalate, phosphate, and azelate esters; chlorofluorocarbons; and nicotine. Typical concentrations of indoor particles were much higher than for those of outdoor particles. The major fatty acids associated with the indoor particles were palmitic, stearic, and myristic. Higher molecular-weight fatty acids, primarily even-number carbon species, were also present. Most of the fatty acids were due to infiltration of particles from outdoors.

0739
Wesolowski, J.J., Sexton, K., Liu, K., and Twiss, S. (1984) "The California indoor air quality program: an integrated approach", Berglund, B., Lindvall, T., and Sundell, J. Eds., "Indoor air, vol. 4, recent advances in health sciences and technology", Swedish Council for Building Research, Stockholm, pp.219-215. NTIS PB85-104180.

KEYWORD: research,regulation,biomonitoring, body, PCP, exposure, design,multipollutant,health,risk,field,control,source,home

Although most states have some mechanism for responding to indoor air quality problems, California is the first to legislatively mandate a permanent research effort to study the nature and extent of the problems. This paper gives a brief history of the program, describes future plans, and discusses some recent work. The integrated nature of the program is illustrated by a study in which environmental and body burden measurements were used to assess potential health effects from indoor exposure to pentachlorophenol.

0606
Wesolowski, J.J., Wang, Y.Y., Hanson, C.V., Haas, R., Flessel, P., and Hayward, S. (1986) "Indoor air quality measurements: emerging technologies", Hochheiser, S., and Jayanti, R.K.M., Eds., "Proceedings of the 1986 EPA/APCA symposium on the measurement of toxic air pollutants", EPA 600/9-86-013, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711, pp. 1-15. Not yet available from NTIS. (In press, Air Pollution Control Association, P.O. Box 2861, Pittsburgh, PA 15230.)

KEYWORD: laboratory, methodology, health, outdoor, home, source, risk,combustion,nitroarene,smoking,mutagenicity,appliance,

Measurement techniques must be geared to the specific needs of the environmental programs they serve. Some of the differences among the three programs on air quality (occupational, outdoor, and indoor) are outlined, and the implications for measurement technologies are discussed. In addition, two emerging measurement technologies are discussed. The first is the development of the Ames Salmonella assay, using a desiccator for detecting vapor-phase mutagens from indoor sources. Data are presented for emissions from a gas range and a kerosene heater, the process of frying hamburgers, and cigarette smoke. The second technique is the use of immunoassays (similar to those used for the detection of infectious agents), which use monoclonal antibodies, for the detection of airborne toxics in environmental and clinical specimens. The immunoassay approach may provide simple, rapid, and cost-effective analysis of large numbers of samples. Preliminary data on the development of antibodies to various nitroarenes are discussed.

0716
Wesolowski, J.J., and Sexton, K. (1984) "California's integrated indoor air program", CA/DOH/AIHL/R-277, California State Department of Health Services, Berkeley, CA 94704 (21 pages).

KEYWORD: home,biomonitoring,exposure,risk,field, control, source, research,PCP,health,regulation,multipollutant,activity

Although most states have some mechanism for responding to indoor air quality problems, California was the first to legislatively mandate a permanent research effort to study the nature and extent of the problem. This paper gives a brief history of the program, describes future plans, and discusses some recent work. Integrating the various facets of an indoor air quality program is emphasized. The integrated nature of California's program is illustrated by a study in which environmental monitoring, body burden measurements, and health status questionnaires were used to assess potential health effects from indoor exposure to pentachlorophenol.

0253
Wesolowski, Jerome J. (1984) "An overview of indoor air quality", J. Environ. Health, 46(6):311-316.

KEYWORD: multipollutant, literature, source, exposure, model, outdoor, methodology, health, control

This overview of nonoccupational indoor air quality covers such topics as the importance of indoor air quality, pollutant sources, differences between indoor and outdoor pollution, health effects, and measurement and mitigation techniques. It also describes the recently legislated California nonoccupational indoor air quality program.

0494
West, P.W., and Reiszner, K.D. (1978) "Field tests of a permeation-type personal monitor for vinyl chloride", Am. Ind. Hyg. Assoc. J., 39:645-650.

KEYWORD: vinyl,personal, exposure, monitor, sampling, laboratory, methodology, halocarbon, field, QA

A passive dosimeter-type personal monitor for vinyl chloride has undergone extensive field testing. Collaborative studies by a number of laboratories confirm the accuracy, reliability, convenience, and general acceptability of personal monitors that use gas permeation for sample collection and quantification. Data are generated as time-weighted averages, and response is linear from 5 ppb to 50 ppm. The monitors, which weigh only 35 grams, are unaffected by variations in environmental conditions.

0278
Whitmore, R.W., and Michael, L.C. (Aug. 1985) "Total human exposure assessment methodology (TEAM), human exposure assessment location (HEAL), vol. 1," EPA contract no. 68-01-6826, U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (83 pages). Not available from NTIS.

KEYWORD: VOC, TEAM, CHCl3, exposure, field, food, benzene, HEAL, methodology, water, EPA$, aromatic, halocarbon

An overview of the workplan for the U.S. Human Exposure Assessment Location: Research Triangle Park (HEAL-RTP) study is provided. Volume 1 provides background information, objectives, compounds to be monitored, and data collection activities for the study, plus a description of the survey instruments and preparation of the data file. Primary emphasis of the study is on investigation of methodologies for monitoring exposure to benzene and chloroform, since inhalation of benzene and ingestion of chloroform via water/beverages is expected to be major exposure routes.

0116
Whitmore, Roy W. (March 1985) "Methodology for determination of uncertainty in exposure assessments", final report for EPA

contract no. 68-01-6826, U.S. EPA, Office of Health and Environmental Assessment, Washington, DC 20460 (86 pages). Not available from NTIS.

KEYWORD: methodology, model, distribution, exposure, statistical, QA, EPA$

Exposure assessments not based on measured exposures for a probability sample of a population rely on a model to predict exposure. The model is a mathematical function that estimates an individual's exposure or the population distribution of exposure as a function of one or more input variables. Whenever an unvalidated model is used to assess an exposure, the uncertainty of the assessment may be large. The primary characterization of uncertainty in this case is at least partly qualitative, i.e., it describes and justifies the model's inherent assumptions. Sensitivity of the assessment can be tested by replicating the assessment with plausible alternative models. When an exposure assessment is based on measured exposures of a probability sample of a population, uncertainty can be quantified and greatly reduced. The primary sources of uncertainty are sampling and measurement errors. A quality assurance program should be designed into the study to ensure that the size of these errors can be estimated and that the effects of all random errors can be measured quantitatively.

0113
Whitmore, Roy W. (in press) "Design of surveys for residential and personal monitoring of hazardous substances", Atmos. Environ.

KEYWORD: home, microenvironment, methodology, personal,exposure, monitor, literature, design

This paper reviews survey design methodology for residential and personal monitoring studies. The recommended methodology is illustrated with regard to four recent studies. Recommendations for design of future monitoring studies are presented.

0239
Whitmore, R.W., Jones, S.M., and Rosenweig, M.S. (Jan. 1984) "Final sampling report for the study of personal CO exposure", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (90 pages). NTIS PB84-181957.

KEYWORD: CO, personal, exposure, monitor, sample,design,economic, QA, methodology, EPA$

This report describes the sample selection procedures used for a study in 1982-83 to evaluate methodology for collecting data on personal CO exposures in the metropolitan areas of Denver, CO and Washington, DC. Based on the experience gained during the study, the methodology developed, with some modifications, may be used effectively in other areas of the country for collecting personal exposure data. These modifications should make the methodology more cost effective, improve the response rate, and lead to more accurate activity information.

0521
Wilkening, Marvin, and Schery, Stephen D. (1984) "Source characterization and transport processes affecting levels of radon and its decay products in an indoor environment", U.S. Department of Energy, Office of Energy Research, Washington, DC 20585 (10 pages). NTIS DE85-005421.

KEYWORD: radon, thoron, ventilation, source, aerosol, exposure, methodology

The effects of pressure variation on diffusion and flow of radon from porous and fractured media were examined, along with other factors that may affect radon exhalation. Natural air-exchange processes in indoor environments were studied to determine their effects on radon, thoron, and their daughter-product progeny. Radon daughter ion-aerosol interactions were discussed. In addition, new instrumentation and methods were developed and evaluated.

0411
Wilkinson, P., and Dimbylow, P.J. (1985) "Radon diffusion modeling", Sci. Total Environ., 45:227-232.

KEYWORD: radon,model, home, source, ventilation, exposure

A mathematical model has been developed that examines the entry of radon into houses through a vertical crack in an otherwise impervious concrete floor. Initially, the model considered the diffusive flow of radon from its soil source. This simulation highlighted the dependency of the flux of radon into the house on the magnitude of various parameters, such as the diffusion coefficient of radon in soil. A preliminary investigation of the modeling of pressure-driven flow into a building is presented, and the potential of this type of analysis is discussed.

0019
Williams, D.C., Whitaker, J.R., and Jennings, W.G. (1985) "Measurement of nicotine in building air as an indicator of tobacco smoke levels", Environ. Health Perspect., 60:405-410.

KEYWORD: nicotine, activity, smoking, office, exposure, control, methodology, ventilation, health

For use in a large office complex, a gas chromatographic technique was devised for collection and analysis of nicotine in the building air as an indicator of tobacco smoke pollution. Segregation of smokers and nonsmokers still resulted in substantial exposure of the nonsmoker to tobacco smoke, although a gradient of exposure was observed. Passive tobacco smoke in the smoking area of the office complex was calculated to be equivalent to 1.1 cigarettes per 8 hours, and nicotine density in this area was 1.96 ug/m. The restriction of smoking to a foyer area outside the office complex resulted in a slow but eventual reduction in nicotine concentrations in the office complex. Observed "background" nicotine levels corresponding to 4% to 7% of those encountered in smoking areas demonstrate that central air circulation systems and people movement increase nicotine levels throughout all rooms of a building, regardless of a smoking policy. Recent documentation of the relationship between passive smoking and cancer, heart disease, pulmonary dysfunction, and allergic responses argues for restriction of smoking to building exteriors.

0318
Wilson, N.K., Lewis, R.G., and Chuang, B.A. (1985) "Analytical and sampling methodology for characterization of polynuclear aromatic compounds in indoor air", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (19 pages). NTIS PB85-188886/AS.

KEYWORD: PAH, ventilation, combustion, smoking, source, sampling, methodology, home, EPA$, wood, appliance

Sampling and analysis methodology were developed for collecting and quantifying polynuclear aromatic hydrocarbons, their nitro derivatives, and their nitrogen heterocyclic analogs in indoor air. The methodology was evaluated in 10 homes, including homes with and without wood-burning fireplaces, gas heat and appliances, and smoking occupants, and having a range of ventilation rates. The range of concentrations in the homes and factors that systematically contribute to concentrations of selected polynuclear aromatic compounds were estimated. Some practical limitations on the sampling equipment and methodology were identified.

0368
Winneke, G., Plischke, K., Roscovanu, A., and Schlipkoeter, H. (1984) "Patterns and determinants of reaction to tobacco smoke in

an experimental exposure setting", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 2, radon, passive smoking, particulates and housing epidemiology", Swedish Council for Building Research, Stockholm, pp. 351-356. NTIS PB85-104198.

KEYWORD: smoking, exposure, health, biomonitoring, CO

In a social setting, 64 nonsmokers were exposed to tobacco smoke corresponding to either 0, 2.5, 5, or 15 ppm of CO. Smoke was produced for 60 minutes by an active smoker. CO was monitored by infrared spectroscopy. Objective (eye-blinks, lacrymal flow, blood pressure, heart rate, and respiration) and subjective measures (questionnaire items) were taken at 20-minute intervals. Before and after the experiment, blood carboxy hemoglobin (COHb) was determined. Significant effects of exposure were found for blinks, lacrymal flow, COHb, and for most of the subjective variables. Only the 15-ppm condition caused significant deviation from control values in most instances.

0315
Withstandley, V., Moroz, W.J., and Anderson, G.W. (1971) "A portable, battery-operated, immediate-readout dust-particle analyzer", J. Air Pollut. Control Assoc., 21(9):571-573.

KEYWORD: particulate, laboratory, field,QA, exposure, industrial, methodology, monitor

A portable, battery-operated, electro-optical dust analyzer has been developed to monitor dust levels in places where external power may be unavailable. The instrument counts and size-discriminates airborne particles over two size ranges upwards of 0.3 um with immediate readout. A dilution mechanism permits analysis of particulate concentrations as high as 2,400 particles/cm3 on each channel. Total operating weight is approximately 14 lb. Good correlation is obtained with results from commercial analyzers. Field studies have been undertaken with the CAES (Center for Air Environment Studies) prototype analyzer at various sites in central Pennsylvania and at numerous sampling points within the cities of Pittsburgh and Philadelphia. Particulate concentrations as high as 1,400 particles/cm3 have been measured at a coal-cleaning plant.

0687
Woebkenberg, M.L. (1982): "A comparison of three passive personal sampling methods for NO2", Am. Ind. Hyg. Assoc. J., 43:553-561.

KEYWORD: personal, exposure, QA, NO2, methodology, monitor

Three personal passive sampling methods for NO2 (Palmes tube, Pro-Tek Colorimetric Air Monitoring System, and Chronotox System) were compared in a laboratory study. Samples were taken at 0.5,5 (the Federal Standard), and 10 ppm for varying time spans of 15-minutes, 4-hours, and 8-hours. Temperature, relative humidity, and face air velocity were held constant. The systems for generating NO2 and determining exposure are presented along with the analytical results and a discussion of error. The Palmes tube successfully sampled at all levels except 0.5 ppm for 15-minutes. It had, however, an increasing standard deviation with increased loading. The Pro-Tek sampler successfully monitored all exposures falling within its linear working range. The Chronotox System sees 0.5 ppm the same as it sees zero concentration, but sampled accurately at loadings higher than 20.9 ppm-hours.

0780
Wooten, G.W., Strobel, J.E., Pustinger, J.V., and McMillin, C.R. (June 1984) "Passive sampling device for ambient air and personal monitoring," U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (61 pages). NTIS PB84-210046.

KEYWORD: VOC, sampling, personal, exposure, monitor, methodology, economic, QA, laboratory, field, halocarbon, EPA$

A high-performance passive dosimeter has been developed and evaluated for monitoring volatile organics in ambient air and for short-term monitoring of low-level personal exposures. The dosimeter design was dictated by three major concerns: (1) diffusive mass transport considerations, (2) sorbent selection, and (3) measurement of the collected compounds, which intimately involves desorption procedures. Salient design features include: (1) ruggedness, simple design, and cost effectiveness; (2) small size and simple operations; (3) high equivalent pump rate and sensitivity; (4) multicomponent sampling capacity; (5) ability to be re-used and recharged; and (6) amenability to thermal desorption. Results of laboratory and field evaluation of dosimeter performance are discussed in terms of the design criteria and application to widely divergent sampling assignments. Detection sensitivity at the sub-ppb level was demonstrated for short exposure time (e.g., 1 hour) employing thermal desorption and halogen specific Hall detector/gas chromatography. Long-term exposures were conducted under ambient air (ppb range) and work station conditions (ppm range). Retention time windows and detector response factors for 24 halogenated compounds have been established for a computer program to increase recognition capability.

0738
World Health Organization (1982) "Human exposure to carbon monoxide and suspended particulate matter in Zagreb, Yugoslavia", GEMS: global environmental monitoring system, EFP/82.33, Geneva, Switzerland (78 pages).

KEYWORD: CO, particulate, seasonal, source, smoking, personal,QA, activity, microenvironment, foreign, Yugoslavia, outdoor

Personal exposure of 10-13 subjects to CO and respirable particles (RP) in winter and summer was estimated in two ways: by personal monitors and by measuring concentrations in indoor microenvironments the subjects were in during a 7-day monitoring period, weighted by the time spent in each microenvironment. The weighted average personal exposure (WAE) was compared to (1) the average of simultaneous measurements of total suspended particulates and RP at the nearest outdoor network station; (2) the concentration to which the subject was exposed at home; (3) the indoor/outdoor concentration ratio; and (4) background concentrations. For people staying indoors all the time, WAEs for both CO and RP correlated best with exposure at home, where they spent about 65% of their time. For CO exposure, the most important factor was the presence of indoor emission sources at home (passive smoking, gas heating or cooking). In the absence of indoor sources, indoor CO concentrations were proportional to background concentrations. The same was true for personal exposure, unless high exposure occurred at work or during commuting. For RP, WAE correlated fairly well with outdoor concentrations in winter. Summer outdoor concentrations were much lower than WAE. This seasonal change shows that a considerable part of personal exposure comes from indoor sources. The instruments used in this study were calibrated, intercompared, and found to give comparable results.

0786
World Health Organization (1984) "Human exposure to suspended particulate matter and sulfate in Bombay, India", GEMS:Global Environment Monitoring System EFP/84.86, Geneva, Switzerland (34 pages)

KEYWORD: particulate, SO4, ventilation, smoking, seasonal, India, personal, exposure, foreign, outdoor

This report presents the results of studies carried out in Bombay, India, relating to human exposure to respirable particulates and sulfates. The personal exposure of 15 people, along with the air quality indoors, outdoors, and at the nearest monitoring site, was monitored simultaneously for 1 year. The subjects were nonsmokers, residing in different parts of Bombay and using different modes of transport such as cars, buses, and electric trains. The study indicates that personal exposure is more than that of air pollution prevailing indoors, outdoors, and at the nearest monitoring site. There is a good correlation between human exposure and air quality indoors, outdoors, and at monitoring sites during both the winter and summer seasons, but there is weak correlation during the monsoon season. Indoor air quality depends on the type of fuel used for cooking and is also affected by nearby sources. The air quality at non-airconditioned hotels and cinemas is better than that at air conditioned places.

0764
World Health Organization (1986) "Indoor air quality research", Report on a WHO meeting, Stockholm, 27-31 August 1984, EURO reports and studies 103, WHO Regional Office for Europe, Copenhagen (49 pages).

KEYWORD: field, exposure, research, multipollutant, risk, design, methodology, control, health, regulation

Following the Third International Conference on Indoor Air Quality and Climate held in Stockholm, Sweden, in August 1984, the World Health Organization Regional Office for Europe held its third Working Group on Indoor Air Quality Research. The working group's report focused on these research areas: (1) laboratory research needs, (2) field studies on total population exposure and total health impact, including sample selection, standardized questionnaires, and measurement protocols, (3) the "sick building syndrome", including symptom identification, methodology, and future research guidlines, and (4) exposure reduction strategies. The group's recommendations focused primarily on field study needs.

0787
World Health Organization (1982) "Human exposure to SO2, NO2 and suspended particulate matter in Toronto, Canada", GEMS:Global Environmental Monitoring System EFP/82.38, Geneva, Switzerland (47 pages).

KEYWORD: NO2, particulate, exposure, field, statistical, SO2, monitoring, foreign, Canada, monitor, outdoor, home

This report describes studies carried out in Toronto, Canada, relating to human exposures to SO2, NO2, and suspended particulate matter (SPM). The first step in the investigation was the development and calibration of a ligh-weight portable sampler for the SO2, NO2, and SPM at the Gage Research Institute. Using a number of samplers, a 1-year field study was carried out in which concurrent measurements were made at indoor sites, at immediately adjacent outdoor sites, and at a downtown ambient air quality monitoring station. In addition, personal samplers were carried by volunteers living in the houses where the indoor samples were collected. The volunteers consisted of asthmatic persons and matched controls living nearby. A survey was made of house and relevant life-style characteristics of the volunteers, and a daily record was kept of other substances to which the volunteers might have been exposed (e.g. tobacco smoke, car exhaust). In general, however, the strategy used was to exclude houses with significant indoor sources of pollution (e.g., gas stoves). It was concluded that quantification of a person's exposure can best be obtained with a sampler.

0718
World Health Organization (1983) "Assessment of human exposure to selected organochlorine compounds through biological monitoring", WHO, Division of Environment Health, CH-112, Geneva, Switzerland (134 pages).

KEYWORD: exposure,biomonitoring,food,methodology,monitoring,dose, halocarbon,demographic,pesticide,multinational,foreign,QA

This report describes development and results of the organochlorine compounds (OCCs) component of the UNEP/WHO Pilot Project on Assessment of Human Exposure to Pollutants through Biological Monitoring. The immediate objectives of the pilot project were (1) review and agree internationally on selected tissues and body fluids; (2) provide technical advice and arrange training programmes for scientists and technicians; (3) design and implement a programme for rigid quality control in connection with sampling, transport, storage and analysis of tissues and body fluids; and (4) carry out a number of pilot studies on selected segments of the population in a specified number of countries. Ten countries have participated in monitoring of OCCs: Belgium, Federal Republic of Germany, India, Israel, Japan, Mexico, People's Republic of China, Sweden, USA, and Yugoslavia. Selected OCCs (mainly DDT, DDE, hexachlorocyclohexane and PCBs) were determined in human milk to provide a measure of exposure to these persistent environmental pollutants. The monitoring results clearly show that there are considerable differences in human exposure to various OCCs in different countries. The results of the present project strongly emphasize the need for quality assurance in biological monitoring for OCCs. Because data involved a limited number of samples, usually collected in the same geographical areas, from 10 countries, it was not possible to draw far-reaching conclusions from them. Extending this kind of biological monitoring to more developing countries, e.g. those in Africa and South America, would give better global coverage.

0762
World Health Organization (1983) "Indoor air pollutants: exposure and health effects", EURO Reports and Studies 78, WHO Regional Office for Europe, Copenhagen. (42 pages).

KEYWORD: Europe, exposure, multipollutant, health,model,indoor, foreign,monitor,source,control,ventilation,CO,smoke,SO2,CH2O,NO2

The meeting or the Working Group on Assessment and Monitoring of Exposure to Indoor Pollutants (convened by the World Health Organization Office for Europe in collaboration with the Federal Republic of Germany) (1) reviewed current knowledge about sources of a number of indoor pollutants, (2) assessed measurement technology and the adequacy of the available data for estimating population exposure, and (3) discussed health impacts and exposure-effect relationships for the purpose of estimating total public health impacts. Pollutants considered were tobacco smoke, NO2, CO, radon, formaldehyde, SO2, CO2, O3, asbestos, mineral fibers, organics, and allergens. For each pollutant, total population exposure was estimated for varying concentrations. Where possible, this information was used to estimate adverse health impact on a given population. The Working Roup concluded that (1) the instrumentation for measuring exposure was usually acceptable, but that the monitoring data and knowledge about the distribution of sources and concentrations were inadequate or marginal and (2) current information did not yet allow quantitative assessments of public health impact. The group recommended future research priorities focussing on formaldehyde, building materials, furnishings, SO2, O3, NO2, CO, monitor development, and representative population sample surveys.

0785
World Health Organization (1987) "Human exposure assessment location - HEAL Project", GEMS:Global Environment Monitoring System WHO/PEP/87.1, Geneva, Switzerland (29 pages).

KEYWORD: exposure, foreign, Kenya, home, biomass, statistical, particulate, combustion

Repeated 24-hour measurements of respirable particulate were carried out in 36 randomly selected houses in Kenya. Most of the cooking was done on open fires using firewood or crop residues. Hourly measurememnts were made between 6 a.m. and 10 p.m. to observe peak values. A questionnaire was used to collect information on demographic, house, fuel, and cooking characteristics. Analysis of variance showed little or no correlation between pollution levels and house characteristics. Also, very homogeneously distributed concentrations were found among the houses.

0297
Wright, C.G., Leidy, R.B., and Dupree, H.E. (April 1981) "Insecticides in the ambient air of rooms following their application for control of pests", Bull. Environ. Contam., Toxicol., 26(4):548-553.

KEYWORD: bendiocarb, pesticide, diazinon, carbaryl,fenitrothion, field, acephate, propoxur,exposure,chlorpyrifos

Insecticides were measured in the ambient air of North Carolina State University dormitories following their application for pest control purposes. Acephate, chlorpyrifos, diazinon, fenitrothion, bendiocarb, carbaryl, and propoxur were applied. The highest insecticide concentrations were present in ambient air immediately following application. The concentration of propoxur was the highest detected; 1.1% carbaryl was present in the smallest amount.

0009
Wright, C.G., and Jackson, M.D., (Jan. 1975) "Insecticide residues in non-target areas of rooms after two methods of crack and crevice application", Bull. Environ. Contam. Toxicol., 13(1):123-128.

KEYWORD: pesticide, ventilation, chlordane, diazinon, field

The movement of insecticides to nontarget areas following application with compressed-air sprayers is appraised and compared with that following application with aerosol-type sprayers. Significantly less movement of insecticides to nontarget areas occurs with the aerosol-type sprayer than with the compressed-air sprayer.

0654
Wright, G.R., Jewczyk, S., Onrot, J., Tomlinson, P., and Shephard, R.J. (1975) "Carbon monoxide in the urban atmosphere: hazards to the pedestrian and street worker", Environ. Health, 30:123-129.

KEYWORD: CO, outdoor, risk, exposure, health, microenvironment, ventilation, foreign, Canada, weather

CO concentrations encountered by pedestrians and workers in the streets of Toronto, Canada, were monitored by a reliable and sensitive portable Energetics Science, Inc. Ecolyzer. Up to 1,000 observations per day were collected for several months during the summer and fall of 1973. CO levels ranged from 10 to 50 ppm, varying with wind speed and direction, atmospheric stability, traffic density, and the height of nearby buildings. Much higher average concentrations were found in such adverse sites as poorly ventilated underpasses and underground garages. Temporary street closures resulted in higher CO levels in some areas, with no change or lower CO levels in other areas. Special risk groups and microenvironments are discussed. The authors suggest that the urban 8-hour CO ceilings of 15 ppm (Ontario Revised Regulation/1970) may be a more appropriate air quality target for street-workers than the usual 8-hour industrial figure of 50 ppm.

0298

Wright, C.G., and Leidy, R.B. (April 1984) "Insecticide residues in the air of buildings and pest control vehicles", Bull. Environ. Contam. Toxicol., 24(4):582-589.

KEYWORD: pesticide, diazinon, chlorpyrifos, malathion, vehicle, interior, field, office

The amount of insecticide present in the air of commercial pest control buildings, service vehicles, and food-preparation areas following routine insecticide application was investigated. The ambient air of office rooms contained significantly less diazinon, chlorpyrifos, and malathion than storage rooms contained. Higher residues of chlorpyrifos were present in ambient air of food-preparation areas immediately after application than were present 24 hours later. Diazinon residues were present in all service vehicles examined. Insecticide levels in all rooms and vehicles were far below allowable limits.

0295

Wright, C.G., and Leidy, R.B. (1982) "Chlordane and heptachlor in homes treated for termites", Bull. Environ. Contam. Toxicol., 28(5):617-623.

KEYWORD: pesticide, chlordane, heptachlor, field, exposure, home

Chlordane and heptachlor are used to prevent and control termites in buildings. A study was initiated to determine ambient levels of these insecticides in houses after chlordane or chlordane plus heptachlor treatments. All air samples taken after application contained insecticides. Levels in the ambient air of the test houses varied greatly, with no discernible or predictable pattern.

0504
Wyndham, S.T., Savage, E.D., and Phillips, C.R. (1978), "The effects of home ventilation systems on indoor radon - radon daughter levels", U.S. EPA, Office of Radiation Programs, Washington, DC 20460 (26 pages). NTIS PB-291925.

KEYWORD: radon, ventilation, home, field, exposure, EPA$, control

A study was conducted in a house in Polk County, FL, to determine the effects of normal home ventilation methods on radon, radon progeny, and working levels. Three normal ventilation conditions (central air conditioning, the central blower without air conditioning, and outside air ventilation) were studied, with radon, radon progeny, and working levels measured sequentially until significant changes ceased. In all three experiments, all three parameters decreased, with the decreases corresponding to estimated increases in house ventilation rate.

0707
Yamanaka, S., Hirose, H., and Takada, S. (1979) "Nitrogen oxides emissions from domestic kerosene-fired and gas-fired appliances", Atmos. Environ. 13:407-412.

KEYWORD: NOx, source, appliance, methodology,combustion, foreign, Japan

NOx emission rates in Japan from appliances for heating, cooking, supplying hot water, and bathtub heating were classified as to emission characteristics and fuel type. Hot water heaters and bathtub heaters emitted the most NOx. These NOx source classes are ranked. The emission rates and the ranking are similar to other published studies. Also, different methods of NOx measurement were compared.

0028
Yanagisawa, Yukio, and Nishimura, Hajime (1982) "A badge-type personal sampler for measurement of personal exposure to NO2 and NO in ambient air", Environ. Int., 8:235-242.

KEYWORD: NO, NO2, personal, exposure, monitor, sampling, QA

Badge-type personal samplers were developed for measuring personal exposure to NO2 and NO without interfering with the wearer's daily activities. NO2 was measured by the sampler with a sensitivity of 124.8 ug/m3 (66 ppb hours) and an accuracy of +/- 20%. After a small modification to the sampler, sensitivity and accuracy for NO were nearly equal to that for NO2.

0565
Yates, A., Gray, F.B., Misiaszek, J.I., and Wolman, W. (1986) "Air ions: past problems and future directions", Environ. Int., 12(1-4):99-108.

KEYWORD: ion, outdoor, literature, health, humidity, demographic, methodology, statistical, weather, particulate

Research on the effects of positively and negatively charged air ions has been hampered by serious methodological flaws, including incomplete assessment of the microclimate, deficient quantification of ion concentration and delivery, and inadequate preparation of the subject or experimental chamber. Variables such as weather sensitivity, gender, and age rarely have been considered. Efforts are underway to standardize the experimental approach. Results from a handful of recent studies suggest that positive ions exert adverse effects and negative ions exert beneficial effects on some indices of physical state, psychological state, and performance. The neurohormone, serotonin, may play a role in mediating these effects, although the nature of the relationship is obscure. Further research in this area is warranted.

0460
Yeates, D.B., Goldin, A.S., and Moeller, D.W. (1972) "Natural radiation in the urban environment", Nucl. Safety, 13(4):275-286.

KEYWORD: radiation,radon,office,outdoor,home,methodology, health, ventilation,source,control,exposure,literature,architecture

This article summarizes previous work on natural background radiation levels and reports new data from Boston, MA. Gamma dose rates, corrected for cosmic radiation, were measured with large ionization chambers. Dose rates inside wooden single-family dwellings were 25 to 50% lower than those outside and, in masonry multiple-family dwellings, were about 10% lower. Concentrations of radon daughters were measured by predecay and postdecay alpha spectrometry. Concentrations in dwellings were comparable with outdoor concentrations, but concentrations in basements were higher by a factor of about 5. Concentrations in office buildings were quite low, because the radon daughters were removed by the ventilation system. Effects on human dose of building type, construction materials, and ventilation are discussed, as are possible ways of reducing population dose.

0484
Yocom, J.E., Clink, W.L., and Cote, W.A. (1971) "Indoor/outdoor air quality relationships", J. Air Pollut. Control Assoc.,

21(5):251-259.

KEYWORD: outdoor, seasonal, particulate, CO, SO2, home, sampling, field, ventilation, source, control, office

A pilot study program was undertaken to obtain data on the quantitative relationship of indoor to outdoor air quality levels for several pollutants. Suspended particulate, soiling particulate, CO, and SO2 were measured at pairs of public buildings, office buildings, and private homes during the summer, fall, and winter seasons of 1969-70. A unique mobile equipment package permitted simultaneous sampling of indoor and outdoor air for diverse building structures. Each pair of buildings was sampled simultaneously for a 2-week period. Two outside and two inside sampling points were selected at each structure. Suspended particulate samples were collected day and night for 12 hours, soiling particulate samples for 2 hours, and gaseous samples for 5 minutes. The results show the ease of penetration of particulate into private homes and the removal ability of air conditioning systems. Outdoor daily activity greatly influences particulate levels and urban CO levels. Internal generation of pollutants was a signficant factor in some of the structures sampled.

0435
Yocom, John E., et al. (1982) "Indoor-outdoor air quality relationships: a critical review", J. Air Pollut. Control Assoc., 32:904-920.

KEYWORD: research, outdoor, exposure, regulation, methodology, literature, multipollutant

Formal presentations by Mr. Yocom, Dr. Moschandreas, Dr. Spengler, Dr. Biersteker, and Mr. Howlett at the 75th Annual Meeting of the Air Pollution Control Association in New Orleans, LA, are reproduced. In addition, comments made from the floor and through the mail are included, along with closing remarks by Mr. Yocom. These presentations review the history and 1982 status of indoor/outdoor air quality research. The relative value of numerical modeling and monitoring surveys is debated. The need for strong Federal coordination of indoor air quality research is asserted. Indoor air often is more toxic that outdoor air, but not enough is known about indoor air pollution to propose a general regulatory strategy.

0094
Yocom, J.E. (Aug. 1984) "Use of direct analysis mass spectrometry to solve indoor air quality problems", Berglund, B., Lindvall, T., and Sundell, J., Eds., "Indoor air, vol. 4, chemical

characterization and personal exposure", Swedish Council for Building Research, Stockholm, pp. 245-250. NTIS PB85-104214.

KEYWORD: CO, VOC, source, methodology, QA, energy, office

Complaints about poor indoor air quality are becoming more commonplace as buildings are made more energy-efficient and as the public becomes more aware of indoor air quality and its potential effects on human health. Standard occupational health sampling methods are usually too insensitive to identify the specific agents causing complaints, since many of the causative agents are complex mixtures of extremely low concentrations of organic gases and vapors. This paper describes the use of a direct reading, mobile mass spectrometer system to identify specific indoor irritants in two office buildings. In addition, the use of this system to evaluate emissions from a prototype of a new type of office machinery and its potential impact on indoor air quality are decribed.

0412
Yocom, John E. (1982) "Indoor-outdoor air quality relationships: a critical review", J. Air Pollut. Control Assoc., 32:(5)499-520.

KEYWORD: outdoor,smoke, particulate, exposure,regulation,home,CO, NOx, source, control

This paper explores an important aspect of air pollution that has played no part, as yet, in setting air quality standards. Doubtless, this results from the very recent recognition that some U.S. criteria pollutants may often be considerably higher in residences than in the outside air, plus the discovery of elevated concentrations in residences of air contaminants that are absent from, or are at much reduced levels, in the outside air. The paper illustrates and comments on the many sources of major pollutants that originate indoors, principally in the home. They include shockingly high concentrations of CO and NOx from the operation of all types of gas-burning appliances and of respirable suspended particulate matter from tobacco smoke. The review contains many comments on rational ways to reconcile this new insight about the significance of indoor air pollutants on health with current air quality standards and recommends ways to incorporate this knowledge into improved standards for the future.

0247
Yocum, John E. and McCarthy, Sharon M. (Feb. 1986) "Tight Building Syndrome", Building Operating Management magazine reprint (4 pages).

KEYWORD: monitoring, smoking, field, ventilation, source, energy, multipollutant,exposure,foreign,Canada,office,sampling,VOC

This article summarizes the indoor air pollution problem that is faced by office building managers. Three case histories are examined; (1) a compilation of generalized results from surveys conducted in the United States and Canada, (2) the investigation of a public building in Washington State after the installation of new carpeting, and (3) the investigation of a new energy efficient office building in Hartford, CT. Reducing ventilation in recent years to save energy has allowed pollutants from indoor sources to accumulate indoors. Organic chemical concentrations in the ppm and ppb range are the most common problem. Developing clear-cut cause and effect relationships is difficult. Investigations into these problems must be multidisciplinary, and controls are usually site and situation specific.

0511
Young, R.A., Berk, J.V., Hollowell, C.D., Pepper, J.H., and Turiel, I. (1981) "Indoor air quality and energy-efficient ventilation rates at a New York City elementary school", U.S. Department of Energy, Office of Buildings and Community Systems, Washington, DC 20585 (65 pages). NTIS DE81-028548.

KEYWORD: CO2, CO, O3, energy, NOx, odor,particulate,CH2O, school, SO2, ventilation, outdoor, aldehyde, radon

A mobile laboratory monitored air quality in two classrooms, a hallway, and outdoors at Oakland Gardens Elementary School in New York, NY, under three ventilation rates. Air-exchange rates, particulates, odor perception, CO2, CO, SO2, O3, NOx, Rn, formaldehyde, and total aldehydes were measured. When the ventilation rate was reduced, CO2 concentrations increased significantly, but did not exceed current occupational standards. At the low ventilation rate, odor acceptability decreased; and in one of the classrooms, the odors were judged unacceptable according to current American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) standards. Calculations indicate that moderate energy savings can be achieved by reducing classroom ventilation rates.

0434
Zarcone, M.J., Schery, S.D., Wilkening, M.H., and McNamee, E. (1986) "A comparison of measurements of thoron, radon and their daughters in a test house with model predictions", Atmos. Environ., 20:1273-1279.

KEYWORD: radon, thoron, home, source, seasonal, exposure, field, ventilation, weather, model, architecture

Airborne thoron, radon, and their decay products were measured in a one-story test house at various periods during four seasons. Meteorological variables, ventilation rates, flux density from soil and building materials, and aerosol concentration were also measured. Time-dependent results indicate significant changes in radon, and the daughters of radon and thoron, in response to meteorological conditions. In comparison, thoron was relatively more stable. Measurements for time-dependent behavior and average disequilibrium ratios seemed to agree reasonably with predictions for a model for indoor radioactivity that uses first-order sink and source terms. The major source for both thoron and radon appears to be the soil.

0151
Zelon, H., Monroe, N., and Whitmore, R. (Oct. 1982) "Field interviewer's manual, (project 2390-4), monitoring of carbon monoxide exposure", Research Triangle Institute, NC 27709 (79 pages). Not available from NTIS.

KEYWORD: CO, field, methodology,biomonitoring,personal, exposure, EPA$

All field activity procedures and forms are given that were used by the field interviewers participating in the U.S. EPA's Washington Carbon Monoxide Exposure Monitoring Study of the winter of 1982-1983. Among the procedures described are delivering personal exposure monitors (PEMs) and study materials to the respondents, explaining their use, returning in approximately 24 hours to collect the PEMs and study materials, cancelling and rescheduling appointments, taking breath samples, and filling out data-collection forms.

0030
Ziskind, Richard A., Fite, Kenneth, and Mage, David T. (1982) "Pilot field study: carbon monoxide exposure monitoring in the general population", Environ. Int., 8:283-293.

KEYWORD: CO, field, personal, exposure, monitor, methodology, EPA$, activity, microenvironment

A pilot field study was conducted with nine members of the general public to measure CO exposure using personal monitors. The principal objectives were to design and evaluate the research protocols and instrumentation for application to a large-scale personal monitoring program. Integrated CO exposure for each subject was monitored and recorded for approximately 45 days according to type of activity, such as "commuting" or "at work". All subjects except one were able to handle both the equipment and data-recording requirements with no significant problems. Actual data-recording responsibilities consumed less than 10 minutes daily. The data consisted of 355 person-days, each over 6 hours on weekdays only, from which 8-hour average personal exposure levels could be computed. The 8-hour National Ambient Air Quality Standard of 9 ppm was exceeded on 22 person-days. Elevated CO concentrations during commuting were frequently associated with the exceedences.

0333
Ziskind, R.A., Rogozen, M.B., Carlin, T., and Drago, R. (1981) "Carbon monoxide intrusion into sustained-use vehicles", Environ. Int. 5:109-123.

KEYWORD: source, field, vehicle, interior,personal, exposure, CO, monitor, outdoor, EPA$

CO exposures were measured in the passenger sections of 1,164 buses, taxis, and police cars in the metropolitan areas of Boston, MA, and Denver, CO. The objectives were to identify high-CO vehicles and to elucidate the mechanisms for high passenger exposures. Vehicle fleets were initially screened with passive dosimeters and pump-driven personal samplers. Selected vehicles were then outfitted with portable electrochemical-cell continuous analyzers coupled to recorders. Principal CO sources and intrusion pathways were pinpointed, using an inert tracer gas (SF6) detection system. Intrusion tests were made both at idle and with the vehicles in motion. Fixed-station monitoring values were underpredicted, in a nonuniform manner, out-of-vehicle CO exposures determined by the field measurements. In 58% of the 120 personal sampler readings for rides greater than 8 hours, the 8-hour National Ambient Air Quality Standard for CO (9 ppm) was exceeded.

0119
Ziskind, R.A., et al. (March 1983) "Carbon monoxide intrusion in sustained-use vehicles", U.S. EPA, Environmental Monitoring Systems Laboratory, Research Triangle Park, NC 27711 (160 pages). NTIS PB83-209999/LL.

KEYWORD: CO, vehicle, interior, ventilation, personal, exposure, field, EPA$

This field investigation was begun with the main objective of measuring CO levels in the passenger area of sustained-use vehicles (principally buses, taxis, and police cars). Attempts were made to identify traffic, operating, and environmental conditions, and vehicle types that could lead to relatively high interior CO exposures. Over 1,000 vehicles were tested in two cities. All vehicles were in use in a working fleet at the time of testing. In over 50% of the 132 vehicle trips checked by personal samplers, the average CO concentration exceeded the National Ambient Air Quality Standard of 9 ppm over 8 hours. In 5% of the cases, the Occupational Health and Safety Administration standard of 50 ppm average for 8 hours was exceeded. Sources of fugitive emissions and intrusion pathways were identified in all vehicles with elevated CO levels.

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